Helsinki School of Economics

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PREDICTABLE VARIATION IN EXPECTED RETURNS:

Commodity Futures in Diversified Portfolios

Master's Thesis
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TUTKIMUKSEN TARKOITUS

Tämän tutkielman tavoitteet voidaan jakaa kahteen osaan. Yhtäältä tutkielma käsittelee ennustettavissa olevaa vaihtelua tuottojen odotusarvoissa hyödykefutuurimarkkinoilla, missä ennustavina muuttujina ovat aiemmassa tutkimuksessa esille tuodut taloudelliset muuttujat. Toisaalta tutkitaan viiden laajan hyödykefutuuriluokan ominaisuuksia investointikohteena sijoitussalkussa, joka sisältää osakkeita, joukkovelkakirjalainoja ja valtionvekseleitä. Löydökset tutkimuksesta johtavat uuteen tavoitteeseen. Lopputuloksena saatava sijoitusstrategia hyödyntää talouden eri sykleistä riippuen tuottojen odotusarvojen vaihtelua.

Tutkielma laajentaa olemassa olevaa tuottojen rationaaliseen vaihteluun liittyvää rahoitustutkimusta keskittyen tuottovaihtelun samankaltaisuuteen sijoituskohteiden välillä. Tutkielmassa havaitaan hyödykefutuurien tuottovaihtelun olevan osittain päinvastainen eri talouden sykleissä osakkeisiin ja joukkovelkakirjalainoihin verrattuna. Löydös kyseenalaistaa Faman (1991) väitteen tuottovaihtelun samankaltaisuudesta kaikissa sijoituskohteissa. Lopuksi tutkielmassa esitetään hyödykefutuurisijoituksen kannattavuus lisänä tyypilliseen sijoitussalkkuun ja näytetään, kuinka rahapolitiikan tiukkuutta voidaan hyödyntää päätöksenteossa kohdennettaessa varoja hyödykefutuurien ja muiden sijoituskohteiden välillä.

LÄHDEAINEISTO

Tutkimuksessa käytetyt hyödykefutuurit kuuluvat Goldman Sachs Commodity Indexiin ja sen viiteen alaluokkaan. Tämä lienee ensimmäinen tutkimus, jossa paneudutaan laajan hyödykeindeksin eri alaindeksien menestykseen. Muut sijoitukset muodostuvat osakkeista, joukkovelkakirjalainoista ja valtionvekseleistä. Näiden lisäksi tutkimuksessa käytetään seitsemää taloudellista muuttujaa, jotka ovat peräisin aiemmasta rahoitustutkimuksesta. Tutkimusaineisto kattaa aikavälin helmikuusta 1987 helmikuuhun 2002. Analyysissa käytetään kuukausihavaintoja. Tutkielman aineisto on hankittu Datastream -tietokannasta.

TULOKSET

Tutkielmassa havaitaan, että taloudelliset muuttujat ennustavat tilastollisesti merkittävästi energia-, metalli ja GSCI -futuurien tuottojen vaihtelua. Lisäksi todetaan kyseisten muuttujien ennustavan tuottoja osittain päinvastaisesti eri sykleissä hyödyke-, osake- ja joukkovelkakirjalainamarkkinoilla.

Tutkielmassa havaittu hyödykefutuurien tuottovaihtelun päinvastaisuus muihin sijoituskohteisiin verrattuna on myös taloudellisesti hyödynnettävissä. Tutkielmassa käytetään rahapolitiikan tiukkuutta kuvaavaa *ex ante* -mittaria, jolla tutkimusjakso jaetaan kahteen ajanjaksoon keskuspankin korkopolitiikan mukaisesti. Tuloksena havaitaan, että tehokas sijoitusallokaatio sisältää suurelta osin energia- ja metallifutuureja rahapolitiikan kireiden periodien aikana ja osakkeita vastaavasti ekspansiivisina ajanjaksoina. Tulokset ovat taloudellisessa mielessä merkittäviä. Sijoittaja olisi voinut restriktiivisen rahapolitiikan aikana kasvattaa hyödykefutuureihin sijoittamalla tehokkaan sijoitussalkkunsa vuotuista tuottoa 12%-tasolta 25%-tasolle lisäämättä 12% vuotuista tuottojen keskihajontaa.

AVAINSANAT

Hyödykefutuurit, arvopapereiden tuotot, rahapolitiikka, diskonttokorko

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Abstract
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PURPOSE OF THE STUDY

This thesis has two objectives. First, it examines predictable variation of expected returns in commodity futures markets with economic variables that have been reported to forecast returns on stocks and bonds. Second, it explores the attractiveness of five broad commodity futures classes as investment vehicles in a portfolio consisting of stocks, bonds, and T-bills. A derived objective is to illustrate a trading strategy that capitalizes on the finding of dissimilar variation in returns across asset classes.

This study expands our current knowledge of the commonality of predictable variation in returns across asset classes. Moreover, the finding of variation in commodity futures returns that moves in a dissimilar cycle compared to stocks and bonds questions the prediction of Fama (1991) that the variation should be common across asset classes. Last, this study provides an illustration of the attractiveness of incorporating commodity futures into the standard portfolio and how monetary stringency can be utilized to guide allocations between commodity futures and traditional assets.

DATA

The commodity futures investments of the study consist of the Goldman Sachs Commodity Index (GSCI) and its five sub-indexes. This is the first study to shed light on the investment performance of broad sub-indexes of a standard commodity futures index. The investments data also include stock, bond, and T-bill indexes. Furthermore, the study employs seven economic variables utilized in past return predictability research. The period of the study expands from February 1987 to February 2002 and the analysis uses monthly observations of the data. The source for the data is the Datastream service.

RESULTS

The results from examining the predictive power of economic variables on commodity futures suggest that previously identified economic variables have significant forecast power on energy, industrial metal, and the GSCI futures. Furthermore, the results indicate that the predictive power of economic variables moves dissimilarly in commodity futures returns in comparison with stocks and bonds.

The finding of dissimilar variability in returns across asset classes motivates the idea of exploiting the variability in returns. A simple *ex ante* measure of monetary stringency is employed to dichotomize the study period into expansive versus restrictive environments. When using this measure, an investor's efficient portfolio is heavily weighted towards energy and industrial metal futures during periods of restrictive monetary policy, whereas during expansive periods stocks largely dominate the portfolio. The results are economically significant. The introduction of commodity futures to an investor's investment mix during restrictive monetary policy periods increases the yearly return on an efficient portfolio from 12% to 25% without a concomitant increase in the 12% yearly standard deviation of portfolio return.

KEYWORDS

Commodity futures, security returns, monetary policy, discount rate

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1 INTRODUCTION

1.1 Introduction and Motivation for the Study

There is mounting evidence in the finance literature that returns on stocks and bonds are predictable on various economic variables. Many contend that it is a result of rational variation in expected returns, while others argue that this predictability implies market inefficiency. Eugene Fama (1991) discusses the accumulated evidence on the stock return predictability and argues that if the predictability is rational, it should be common across markets.

The primary objective of this thesis is to examine the forecasting power of business condition and monetary policy variables used in the stock return predictability literature in regressions with commodity futures. This study seeks to establish whether there is marginally significant forecasting power on commodity futures in the previously identified economic variables. Bessembinder and Chan (1992) make a similar attempt, although their range of economic variables is far less developed and does not contain any of the monetary variables that were first seriously introduced to this branch of finance literature only by the mid 1990's. However, their study is an important addition to the return predictability literature examining the proposition of Fama (1991) that the rational variation in expected returns should be common across markets.

The results of this part of the study are engrossing. Many of the formerly identified economic variables contain significant forecast power on returns in energy and industrial metal futures, and furthermore, the results suggest that the variation in expected returns moves in a dissimilar cycle in commodity futures when compared with stocks and bonds. This result has implications on construction of efficient portfolios in which commodity futures are incorporated, and this study also attempts to illustrate how the differences in the variation of expected returns between asset classes can be taken advantage of. This brings us to the secondary aim of this study.

There are numerous studies that examine the performance of portfolios that include equities, bonds, and cash equivalents and demonstrate the advantages of adding new asset classes to the standard portfolio. The secondary objective of this study will extend this line of research by focusing on the role of commodity futures in improving the performance of portfolios comprised of stocks, Treasury bonds, and T-bills. Furthermore, this study's finding of variation in expected returns that moves in a dissimilar cycle across traditional assets and commodity futures will be utilized in this context. This thesis will illustrate how an investor could have achieved substantially enhanced returns when employing a simple ex ante measure of monetary stringency to help in guiding the allocations between traditional assets and commodity futures.

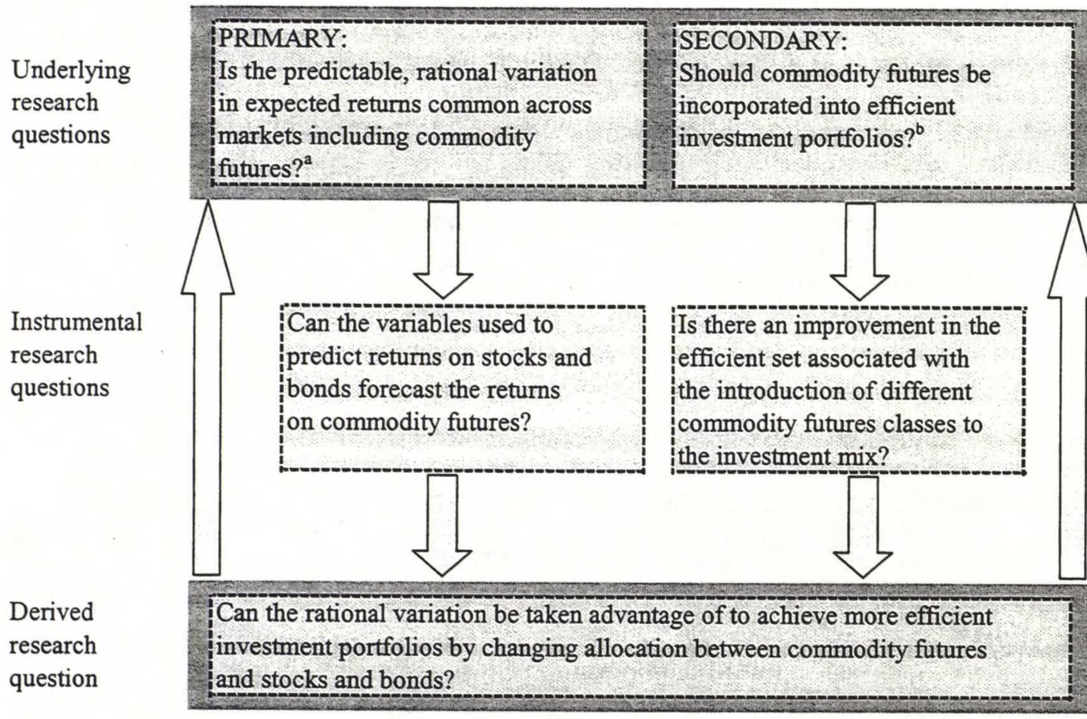
As an early motivation of the economic importance of the findings in this study, it is worthwhile mentioning some interesting results. For instance, if an investor had used the monetary stringency variable used in this study in guiding portfolio allocations between stocks, Treasury bonds, T-bills, and commodity futures during the period of study from February 1987 to February 2002, the investor's risk-return tradeoff would have enhanced substantially. During periods of restrictive monetary policy an investor's efficient portfolio would have experienced an increase in the yearly return, associated with the introduction of commodity futures to the investor's investment mix, from approximately 12% to almost 27% without concomitant increase in the portfolio volatility at the 14% yearly standard deviation of portfolio returns. This result demonstrates the advantages of adding commodity futures to the standard portfolio and it also illustrates how predictable variation in returns across asset classes that moves in a dissimilar cycle can be taken advantage of.

1.2 Research Questions

Formally, the aim of the study arises from the research questions that are depicted in figure 1 which shows the logical path of the study starting from the initial research questions that are strongly motivated by findings of earlier researchers. The reason for dividing the underlying research question to a primary and secondary question is the fact that I feel that the primary question is far less researched and hence also contributes more to the existing literature. As

FIGURE 1
Formulation of Research Questions

Figure 1 depicts the evolution of this study from a primary and secondary research question into a derived research question that manifests itself as a symbiosis of the underlying research questions and the results of the instrumental research questions.



[a]The predictability or rational variation in expected returns conditional on economic variables has been extensively researched during the past 15 years or so. This study is motivated by and strongly relies on earlier findings on this topic.[1]
[b]The use of commodity futures in investment portfolios is a thoroughly research topic. There is however no clear consensus of their attractiveness as a portfolio component[2]

figure 1 shows, the underlying research questions conflate to a derived research question to which the answer will shed light on the underlying research problems.

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[1] Studies by Fama and French (1989), Fama (1990), Schwert (1990), Keim and Stambaugh (1986), Campbell (1987) find that stock and bond returns are predictable on a common set of stock market and term structure variables. Harvey (1991) finds that dividend yield on the S&P500 and portfolio and U.S. term structure variables forecast returns on portfolios of foreign common stocks. Studies that report predictable variation in stock and bond returns captured by monetary policy include Jensen, et al. (1995, 1996, 1997), Booth and Booth (1997), Patelis (1997), Durham (2000). Bessembinder and Chan (1992) report forecast ability of three economic variables on a range of commodity futures.

[2] Studies on the use of commodity futures as an investment vehicle in portfolios discussed later include Bodie and Rosansky (1980), Bodie (1983), Irwin and Brorsen (1985), Elton, et al. (1987), Elton, et al. (1990), Irwin, et al. (1993), Anson (1999) and Jensen, et al. (2000).

1.3 Objectives of the Study

The primary objective includes

- to identify whether common economic variables can forecast also returns on commodity futures, and if they can, which particular commodity futures classes
- to identify whether the variables that forecast returns move in similar cycles across asset classes, or whether the forecast results suggest revising portfolio allocations depending on the state of the economy.

The secondary objective includes

- to evaluate the attractiveness of commodity futures and the different commodity futures classes as portfolio components.

And an emergent objective arises from the answer to the primary question, namely

- to identify a trading strategy that capitalizes on predictable variation of expected returns on stocks, bonds, and commodity futures.

1.4 Contributions of the Study

The results of this study contribute directly to our existing understanding of the nature of predictability in asset returns. The results question fundamentally the predictions of Fama (1991) that the forecast power of economic variables should be similar across all asset classes. Moreover, the dissimilarities in the patterns of variation would have allowed investors that include commodity futures in their portfolios to enjoy extremely attractive returns on their investment portfolios during the 15-year period of study.

The most important findings of this thesis to existing finance literature include

- that economic variables used in the stock return predictability literature forecast returns on energy, industrial metal, and the GSCI futures
- that the forecast power of economic variables moves in a dissimilar cycle across commodities and stocks and bonds implying possibilities for enhanced asset allocation
- that a broad, ex ante measure of monetary stringency can be used to exploit the differences in variation of expected returns in commodity futures and traditional assets. The enhancement in returns is economically very significant, more than

doubling the portfolio returns at higher levels of risk during periods of restrictive monetary policy.

In essence, the contributions of this study are twofold. First, it expands our current knowledge of the commonality of predictable variation in returns across asset classes. Second, it provides an illustration of the attractiveness of incorporating commodity futures into the standard portfolio to complement stocks, bonds, and T-bills.

1.5 Futures Investments Utilized in the Study

The futures investments examined in this study are based on the Goldman Sachs Commodity Index (GSCI)[3]. The GSCI is a world-production weighted commodity futures index that is fully collateralised by posting Treasury bills as a collateral, and is as such comparable to, for example, a regular investment into an equity index like the S&P500. In addition, the GSCI is always invested in nearby futures contracts. As the contracts approach maturity and the delivery date, they are rolled forward into the next nearby contracts during a five-day gradual rolling period during the same business days each month.

Hoping for more active investor participation in the commodity futures sector, Goldman Sachs launched the GSCI in 1991. The GSCI was designed to provide investors with an available benchmark for investment performance in the commodity markets. Despite the fact that products like the GSCI are readily available for investing [the GSCI is traded on the Chicago Mercantile Exchange (CME)], the typical investor hasn't thus far adopted the use of commodity futures in diversifying the investment portfolio.

The results of the empirical part of the study become even more interesting since the futures investments utilized in this study are such that they could relatively easily be done through commodity marketers without fear of excessive transaction costs[4]. Furthermore, the study

[3] See appendix 1 for more details on the GSCI. All the commodity futures investments discussed in the study are GSCI derivatives.

[4] Individual commodities are screened by liquidity for inclusion in the GSCI. The eligibility requirements are designed in order to promote cost-effective implementation and true investability. This underlying liquidity eases hedging of derivative products and investing in subsector or individual commodity overlays. Furthermore, the liquidity in the underlying markets allows easy implementation of the portfolio of futures contracts that the GSCI represents, and that coupled with the simple methodology of constructing the GSCI enables efficient and

uses broad representatives of the performance of each asset class and considers only conservative long-only investments thus attempting to minimize the impact of having chosen indexes that had a specific performance pattern by coincidence.[5] Last, utilizing subindexes of a broad world-production weighted index, the GSCI, ascertains that also the subindexes are diversified comprising of several futures contracts each.[6]

1.6 Structure of the Study

The first chapter of this study has attempted to serve as an introduction to the topics of the rest of the research. Chapter two discusses the theory and empirical findings on commodity futures markets, commodity futures in a portfolio context and the justifications that have been presented for their use as a portfolio component. This helps in answering the secondary research question, but will also be valuable in interpreting the results of the primary research question. The third chapter presents an overview of related research on the role of monetary policy and financial variables in explaining the observed predictability in asset returns and links this research to commodity futures returns. The fourth chapter describes the data used in this study, discusses the methodology and presents the hypotheses. Chapter five presents the empirical results, and some concluding remarks are offered in chapter six.

Figure 2 shows the logical structure of the study more closely and illustrates how different sections link together in answering the research questions presented in figure 1. Figure 2 should be useful in understanding especially how the structure of the empirical section is laid out. It also shows how the primary and secondary objectives overlap and combine in the empirical section.

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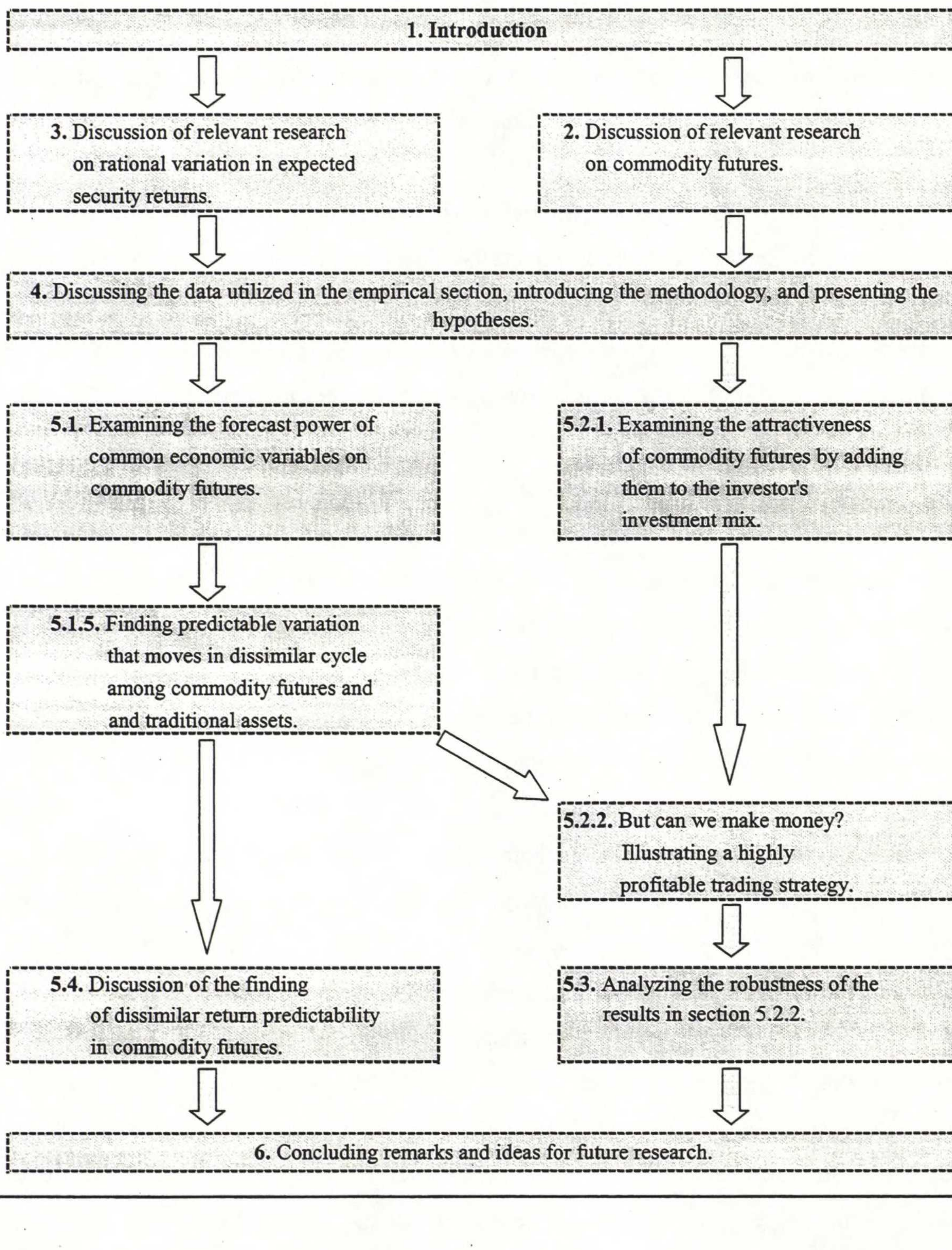
relatively inexpensive arbitrage of publicly-traded GSCI-related instruments such as the CME futures contract. (www.gs.com) Refer to Appendix 1 for more information on the GSCI.

[5] This refers mostly to the fact that I chose the GSCI as the benchmark for investment performance in commodity futures instead of having chosen managed futures. The term *managed futures* represents a whole industry comprising of money management professionals known as *commodity trading advisors* (CTA's) managing their clients' assets by the investment medium of global futures and options markets.

[6] I feel that it is more proper to examine predictable variation captured by macroeconomic variables in a broad futures class such as energy instead of just examining one specific form of energy, such as crude oil futures, since a broad aggregated class of commodity futures acts as a better macroeconomic proxy itself reducing the impact of idiosyncratic, one-off events impacting just one specific futures contract and possibly blurring the forecast power of economic variables.

FIGURE 2
Structure of the Study

This figure shows the logical structure of the study and how the different sections of the study link together in an attempt to examine the research questions presented in figure 1. The left-hand side path is roughly the one that examines the primary research question presented in figure 1 and the right-hand side path is more concerned with the secondary research question. There is, however, some natural overlapping, and especially sections 5.2.2 and 5.3 answer mainly to the derived research question and contribute to the answer to both the primary and secondary research questions.



2 COMMODITY FUTURES AS AN INVESTMENT – DISCUSSION OF THEORY AND RELATED RESEARCH

2.1 Theory of Normal Backwardation

The renowned British economist John Maynard Keynes (1927, 1930) emphasized with his theory of normal backwardation the financial risk for carrying inventories of agricultural products, and his suggestion was that the futures markets exist to facilitate hedging this risk. In his view, the futures prices are unreliable estimates of the spot price prevailing on the date of expiry of the futures contract. In effect, the theory argues that speculators sell "insurance" to hedgers and that the market is normally inefficient because the futures price is not an unbiased estimate of the maturity spot or cash price. Speculators enter the long side of the contract only if the futures price is below the expected spot price at maturity, for a profit of $E(P_T) - F_0$, where $E(P_T)$ is the expected spot price at maturity and F_0 is the futures price. Hence, the theory of normal backwardation establishes that the futures price of a commodity is a downward biased estimate of its spot price at the contract maturity date. This implies that on average there is an excess of short hedgers who wish to avoid the risk of declining commodity price movements and are therefore willing to hedge their commodity positions at a price lower than the expected spot price at the maturity date. This will induce speculators to enter the futures market and to take the opposing positions in the contracts. The opposite situation when the futures price is an upward biased estimate is called contango.

Modern portfolio theory modifies the approaches defined above for the determination of risk premiums. The result is that if commodity prices pose positive systematic risk, futures prices must be lower than expected spot prices. This means that the long side of the contract will make an expected profit when the commodity exhibits positive systematic risk. According to this view, speculators that hold well-diversified portfolios will be willing to enter long futures positions only if they receive compensation for the positive systematic risk of the commodity.

Ever since the formulation of the normal backwardation theory, there has been controversy in the academic literature over the existence of a futures risk premium compensating speculators for bearing risk. In recent years, empirical studies have related expected futures returns to the covariances between futures returns and (1) the returns on the market portfolio; (2) the factors extracted from the covariance matrix of returns; (3) some prespecified factors; and (4) the variation through time in the market returns (Miffre 2000).

The studies investigating the normal backwardation in the context of the CAPM have produced conflicting results. Dusak (1973) found no risk transfer between hedgers and speculators in selected agricultural markets. On the other hand, Carter, Rausser, and Schmitz (1983) researched changing speculative positions within the CAPM and found support for systematic risk and hedging pressure as determinants of commodity futures prices when allowing for changing speculative positions within the CAPM.

Another trend in empirical research in the commodity futures markets has been the use of multifactor models with prespecified risk factors which were first used in the stock markets (see for example Chen, Roll and Ross 1986 for common risk factors). For instance, Young (1991) found no significant risk premium in selected agricultural markets. On the contrary, Bessembinder (1992) found that residual risk conditioned on net hedging is priced in agricultural and foreign currency futures markets, implying that normal backwardation theory has merits in describing agricultural commodity futures prices. Furthermore, the evidence of Bessembinder (1992) showed that futures premia depend not only on systematic risk of the futures contract but also on hedging pressure which is an important determinant of futures prices.

All in all, the studies that assume that the sensitivities of futures returns to some systematic sources of risk are constant have been questioned by the latest finding. The most recent findings by Miffre (2001) and Bessembinder and Chan (1992) question these assumptions and provide evidence on the time variation in expected futures returns. Miffre (2000) suggests that when one allows for time variation in expected futures returns, there is strong evidence of the normal backwardation theory. Miffre (2000) concludes: "When one allows for time variation in expected futures returns, there is strong evidence in favor of a risk transfer between hedgers and speculators in the futures markets."

The two major approaches of the analysis of commodity futures risk premia can be distinguished by their assumptions of the marketability of assets. What is often called the perfect markets approach leads under conventional assumptions to the modern asset pricing theories. The alternative imperfect markets approach is based on the premise that market imperfections, such as moral hazard or adverse selection, limit the issuance of equity shares by commodity producers thus leading to the nonmarketability of some assets. (Hirsleifer 1988a) An implicit assumption of nonmarketability is embedded into the theory of normal backwardation as is into the more recent work on the effects of hedging pressure on futures prices.

2.2 Market Segmentation and Futures Price Bias

Optimal futures hedging and equilibrium futures price bias has been an area of research in many theoretical models and empirical studies in finance. The classical literature on futures price bias and hedging from Keynes (1927) and Hicks (1939) has been refined in many occasions to include non-participation of some investors to the futures market due to fixed setup costs, consumption risk of producers and investors, the participation of refiners in the economy, and there has been the always-present perfect markets approach of determining the futures price bias. All these findings do in some respects explain the importance of adding commodity futures into investment portfolios to enable efficient diversification.

Hirsleifer (1988a) presents an equilibrium model that integrates modern portfolio theory with market imperfections, namely the non-marketability of some claims[7] and limited participation of investors to commodity futures markets due to fixed setup costs. The resulting equilibrium describes futures risk premiums as dependent on both systematic risk and residual risk coming from the net hedging pressure. Hirsleifer (1988a) notes that "It does not take a large monetary or informational cost to deter individuals contemplating small positions from trading the futures contract on a personal account, and intermediaries have held positions on behalf of private investors only to a very limited extent." Furthermore, he notes that regulatory restrictions ban pension funds from trading commodities and that mutual funds do not combine commodity futures and other securities in portfolios.[8] As a result, an investor is

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[7] By non-marketability of claims it is meant that a source of wealth is non-marketable if equity shares are not traded on it. Hirsleifer (1989) states that the issuance of widely-held equity claims by suppliers is minimal in a number of commodity markets possibly due to problems of moral hazard and adverse selection.

[8] The psychological, informational or regulatory reasons for lack of participation on the commodity futures markets are often mentioned in studies researching futures price bias. For instance, Hirsleifer (1989) notes, "Few investors participate in commodity futures markets, either directly or through financial intermediaries such as mutual or pension funds. This may arise from reluctance of uninformed individuals to trade, or from regulatory

forced to resort to a specialized futures fund to form a portfolio in which commodity futures are incorporated (Hirsleifer 1988a). Factors of this like may be causing limited participation in the commodity futures markets and returns that are not in perfect alignment with the modern portfolio theory, thus making it possible for investors to achieve better portfolio allocations by trading in the commodity futures markets. One theoretical model showing this is presented by Hirsleifer (1989) who concludes, "The absence of consumers increases the magnitude of the producer-hedging component of the premium, which can cause the premium to be opposite in sign to that predicted based on the covariance of the futures payoff with aggregate consumption." This implies incorrect pricing of the futures contract in the context of the consumption-based capital asset pricing model.

Hirsleifer (1988a) concludes that the imperfectly marketable revenue risks of producers lead to futures price bias that deviates from proportionality to stock market beta and that setup costs or informational barriers that reduce participation by the speculators on the futures market increase the impact of hedging on the risk premium. Bessembinder (1992) tested the hypothesis of full commodity and other asset market integration against the alternative proposed by Hirsleifer (1988a). As a result, he found that there was a degree of market segmentation implied by deviation of mean returns on agricultural and foreign exchange futures markets from the level predicted by systematic risk alone and that hedging pressure was a determinant of the bias.

Models suggesting that commodity futures and other asset markets are segmented or that the futures price bias deviates from proportionality to stock market beta have implications to investors. First, wrongly assuming that markets are integrated may lead to incorrect adjustments to portfolio risk and suboptimal portfolios.[9] Another possible implication of segmented markets is in the assessment process of whether assets are mispriced.[10]

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or moral hazard constraints to commodity trading by institutional investors. Despite a recent proliferation of futures mutual funds, due to their very active management based on technical analysis, they have not provided a convenient means for uninformed investors to diversify." The launch of publicly traded, liquid commodity futures indexes such as the GSCI in the early 1990's has attempted to alleviate this problem.

[9] If markets are segmented, the price of risk in different markets differs. The implications from the arbitrage pricing theory (APT) perspective are illustrated by what follows. In the absence of arbitrage possibilities the following relationship holds (Ross, 1976):

$$E(R_P) = \lambda_0 + B_P\lambda \qquad (1)$$

where R_P is the return on a portfolio lying on the security market line that includes both commodity futures and other assets, $E(.)$ is the expectations operator, λ_0 is the return on the risk free asset and λ is a K-vector of risk premia associated with risk factors and B_P is the K-vector of sensitivities of the portfolio returns to the K-vector of factors. Furthermore, the expected returns on assets and on commodity futures are

$$E(R_A) = \lambda_0 + B_A \lambda \tag{2}$$

and for futures that require no upfront investment (For discussion of the issue, see Dusak, 1973)

$$E(R_F) = B_F \lambda . \tag{3}$$

The expected return of the portfolio equals:

$$E(R_P) = E(R_A) + H \cdot E(R_F) \tag{4}$$

where H is the relative weight allocated to futures expressed as a proportion of the total wealth of the portfolio. Then, if we substitute equations (1), (2) and (3) into equation (4) and divide by λ, we get a formula for the portfolio factor sensitivity:

$$B_P = B_A + H \cdot B_F \tag{5}$$

where the portfolio quantity of risk is a weighted average (weights are the amounts invested in each asset) of the portfolio components' quantities of risk. If futures and asset markets are not integrated, the price of risk in the two markets differs. Different price of risk in the futures market yields:

$$E(R_F) = B_F \lambda^F \tag{6}$$

where λ^F is the reward per unit of market risk in the futures market. The quantity of risk of the portfolio now considers also the relative prices of market risk across markets (substitute equations (1), (2) and (6) to equation (4) and divide by λ to get):

$$B_P = B_A + H \cdot B_F \lambda^F \lambda^{-1} . \tag{7}$$

Hence, wrongly assuming that markets are integrated can make the portfolio adjustments of risk incorrect and shift the portfolio risk-return tradeoff from its optimal level. [Implications of futures market segmentation were modified from Miffre and Priestley (2000)]

[10] The second claim that market segmentation may hamper the process of discovering asset mispricing can be researched through Jensen's (1968) alpha which is a traditional measure for fund managers to detect mispriced assets (Miffre and Priestley, 2000). If a fund manager wrongly assumes that markets are integrated and prices of risk are equivalent in both markets, Jensen's alpha will yield incorrect results. Assume market integration and that returns are given by the multifactor model:

$$R_{Pt} = E(R_P) + B_P \cdot X_t + \varepsilon_{Pt} \tag{8}$$

then (1) must hold for the absence of arbitrage possibilities [In fact, the assumption that returns are driven by linear the multifactor (8) leads to equation (1), see Ross (1976)]. R_{Pt} is the return on a portfolio including assets and futures at time *t*, X_t is K-vector of factors at time *t*, and B_P is the K-vector of sensitivities of the portfolio returns to the K-vector of factors X_t, and ε_t is a white-noise error term. Substituting equation (1) into (8) yields

$$R_{Pt} - \lambda_0 = \alpha_P + B_P(\lambda + X_t) + \varepsilon_{Pt} . \tag{9}$$

If however markets are segmented, portfolio that consists of futures and other assets has the actual return

$$R_{Pt} = R_{At} + H \cdot R_{Ft} + \varepsilon_{Pt} \tag{10}$$

where R_{Pt}, R_{At} and R_{Ft} are the time *t* actual returns on the portfolio, assets and futures, respectively, and H is the relative weight allocated to futures expressed as a proportion of the total wealth of the portfolio. Assuming markets are segmented and the returns follow linear factor model (8) and risk-expected return relationship (1), then Jensen's alpha and equation (10) becomes (Miffre and Priestley, 2000):

$$R_{Pt} - \lambda_0 = \alpha_P + B_P \cdot X_t + (B_A \lambda + HB_F \lambda^F) + \nu_{Pt} \quad \text{, where } \nu_{Pt} = \varepsilon_{At} + H\varepsilon_{Ft} + \varepsilon_{Pt} . \tag{11}$$

As a result, ranking and hence pricing portfolios under the assumption that markets are integrated is likely to yield different results from the results that relax the wrong assumption. In conclusion, wrongly assuming that commodity futures and other assets markets are integrated may lead to portfolios that are wrongly adjusted for risk or may lead to incorrect inferences in the process of detecting mispriced assets. [Implications of futures

Empirical evidence and theoretical models that derive their assumptions from institutional features like the regulatory frictions of futures markets suggest that other asset markets and commodity futures markets may be segmented.[11] First, as suggested, this has implications to portfolio managers and they should take into account the possible consequences of market segmentation. Second, it may also have implications in the context of asset return predictability implying that asset returns in segmented markets may react differently to macroeconomic events and that an investor may obtain substantial benefits from any predictable variation in expected returns in segmented markets by modifying the portfolio allocations between the different asset and futures classes.

2.3 Risk and Return in Commodity Futures

An important study by Bodie and Rosansky (1980) studied the performance of 23 individual commodity futures contracts over the period 1950 to 1976. Bodie and Rosansky (1980) found that the mean rate and the variance of return on a well diversified portfolio of commodity futures contracts over the 27-year period were close to the mean and variance of the return on the Standard & Poor's 500 common stock portfolio. Furthermore, an important implication of their results was that the market portfolio of common stocks as represented by S&P 500 did not offer the minimum variance for the given mean return during the period. An investor could have achieved a reduction of one third in variance by investing in the futures portfolio with no concomitant decline in mean return (Bodie and Rosansky 1980).

Numerous studies have examined the performance of commodity futures with the results reporting somewhat mixed evidence of their performance. Studies by Bodie and Rosansky (1980), Irwin and Brorsen (1985), Irwin and Landa (1987) and more recently Anson (1999) and Jensen, Johnson and Mercer (2000) support the view that managed or passive commodity futures investments have historically provided favourable and appropriate investment returns. In contrast, Elton, Gruber and Rentzler (1987, 1990) found managed futures to be a poor investment on a portfolio basis. The results seem to be closely tied to the futures investment

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market segmentation were modified from Miffre and Priestley (2000) who empirically test the integration of futures and spot markets in the context of Arbitrage Pricing Theory (APT).]

[11] Evidence of possible commodity futures market and stock market segmentation is presented by, for example, Bessembinder and Chan (1992, 192) who conclude, "Thus, our results suggest that the marginal investor may

and the time-period examined. However, it seems that commodity futures as an asset class should be taken into account in determining the optimal investment portfolios, especially since there are nowadays possibilities for investors to invest in readily constructed commodity indexes and thus the construction of a diversified commodity futures portfolio is no longer left to the investor.

The returns to public commodity pools have been used to test the efficiency of the futures market. Bodie and Rosansky (1980) found that the mean rate of return on their diversified commodity portfolio was well in excess of the average risk-free rate implied by the capital asset pricing model (CAPM) and thus they concluded that their results appeared to be inconsistent with the conventional form of the capital asset pricing model. In contrast, Irwin, Krukemeyer and Zulauf (1993) tested more recently the efficiency of the commodity futures market using the capital asset pricing model and found that the returns to public commodity pools were consistent with the capital asset pricing model during the period 1979-1990. However, Irwin et al. (1993) rejected the hypothesis of market efficiency for institutional commodity pools during the same period. They noted that the excess returns might represent a market inefficiency that is being eliminated by increasing institutional investment in commodity pool programs.

The academic research on commodity futures as an addition to the standard portfolio consisting of stocks and bonds is, as has been discussed, somewhat mixed. It seems that the time-period starting from the 1950's until the year 1980 was clearly a period when commodities should have been incorporated into efficient investment portfolios. The more recent research shows that market efficiency has increased and that substantial enhancements in the risk-return tradeoff may no longer be achievable. However, there exists also recent research [Jensen, et al. (2000) and Anson (1999)] that supports the use of commodity futures indexes in constructing efficient portfolios.

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differ across equities and futures." Theoretical models that implicitly suggest that commodity futures and other asset markets are segmented are presented by, for instance, Hirsleifer (1988 a, b and 1989).

2.4 Commodity Futures as a Hedge Against Inflation

Interest in commodity futures started growing in the late 1960's and 1970's on the back of tremendous increases in inflation in the American economy (Elton and Gruber, 1995). The reason is that during inflationary periods, returns from stocks and bonds tend to be impacted adversely whereas commodity prices rise and long positions in commodity futures benefit (Jensen, Johnson and Mercer 2000). As a consequence, one of the justifications for including commodity futures in portfolios is the view that they provide the investor with a hedge against inflation. Bodie (1983) provides empirical evidence supporting this effect, and concludes that the returns on stocks, bonds and t-bills were negatively affected by inflation during the period 1953-1981, whereas commodity futures performed well during inflationary periods.

This is an interesting result and Bodie (1983) argued that it is an important one for portfolio managers since they should be concerned about real returns and they may wish to incorporate commodity futures to build a hedge against inflation. Moreover, Elton and Gruber (1995) argue that returns on commodity futures should actually only reflect unanticipated inflation, as anticipated inflation should already be incorporated in the pricing of commodity futures. Elton and Gruber (1995) continue:

> *In addition, since price is affected by unanticipated inflation rather than inflation itself, to decide on the timing of purchases of futures one has to predict unanticipated inflation. In other words one has to be a better predictor of inflation than the aggregate of investors (the market).*

The implication of this to the predictability of futures returns would be that variables that may capture changes in unanticipated inflation should be the best ones for capturing variation in futures returns. It also implies that in environments where unanticipated inflation is likely, an investment portfolio should be weighted towards commodity futures, whereas otherwise a more neutral approach and balance towards stocks would be likely to turn out more profitable.

There seems to exist an apparent link between inflation, unanticipated inflation and returns on commodity futures implying that long positions in commodity futures should benefit during inflationary periods. On the other hand, a negative relation between stock returns and (1) expected inflation, (2) changes in expected inflation, and (3) unexpected inflation has been reported extensively (Stulz 1986). For instance, early findings by Fama (1981) and Geske and Roll (1983) provide evidence and a theoretical explanation of the relation between stock returns and changes in expected inflation.[12] On the other hand, an interesting result is the finding that ex ante real returns on common stocks are negatively related to ex ante expected inflation, since one would expect information about future economic activity to be capitalized in stock prices and have no effect on ex ante real stock returns (Stulz 1986). Nevertheless, various theoretical models have been developed attempting to explain the apparent negative relation between expected inflation and expected real returns in an efficient capital market.

The significance of these results becomes clear in the context of utilizing commodity futures in portfolio diversification. Commodity futures should be incorporated into a portfolio to hedge it against inflation or unexpected inflation. Moreover, the optimal portfolio allocations to equities and commodity futures would obviously change according to the levels of inflation, and ability to capture periods of unexpected inflation would prove valuable to an investor.

[12] These studies also essentially link the monetary sector to stock returns, and hence they can also be included as early versions of the literature examining stock return predictability by the monetary sector.

3 ECONOMIC FACTORS, MONETARY POLICY AND EXPECTED SECURITY RETURNS

This chapter discusses asset return predictability literature in which variation in expected returns of different assets has been argued to be rational and predictable by different financial variables. Section 3.1 discusses this literature on a general level. 3.2 introduces the study of Fama and French (1989) that reported predictability conditional on variables that were related to business conditions. The study of Fama and French argued that the predictability may have a rational explanation. Sections 3.3 and 3.4 concentrate on research using monetary policy variables in forecasting asset returns. Section 3.5 discusses the process of interest rate determination from a theoretical perspective to help understand the complexity of interest rate variables used in the predictability literature and the information that they may contain.

3.1 Economic Variables and Expected Security Returns

One important aspect of the *market efficiency* –research in finance has been the issue of return predictability including the burgeoning work on forecasting asset returns with variables like dividend yields, interest rates or monetary policy variables. This section provides an introduction of different areas of this research and links the predictability literature to the empirical section of this thesis.

There is a growing body of research that has focused on forecasting stock, bond and to a lesser extent commodity futures returns using economic factors.[13] For example, Fama and French (1989), Fama (1990), and Schwert (1990) focus on economic factors and find three economic variables to be significant in explaining variation in expected returns on stocks and

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[13] These studies include for example Fama and French (1989), Fama (1990), Schwert (1990) [these studies use common variables as discussed below]. Moreover, Keim and Stambaugh (1986) and Campbell (1987) find that stock and bond returns are predictable on a common set of stock market and term structure variables. Harvey (1991) finds that dividend yield on the S&P500 and portfolio and U.S. term structure variables forecast returns on portfolios of foreign common stocks. Studies that report predictable variation in stock and bond returns captured by monetary policy include Jensen et al. (1996, 1997, 1998), Booth and Booth (1997), and Patelis (1997). Studies that examine stock return predictability in an international context include for example Conover et al. (1999a, 1999b) and Durham (2000). Last, Bessembinder and Chan (1992) report forecast ability of three economic variables on a range of commodity futures.

bonds. The three variables or business condition proxies[14] - the dividend yield, default spread, and term spread – are also used in some more recent studies. For example, Jensen et al. (1996), Booth et al. (1997), and Patelis (1997) peruse the robustness of these business condition proxies and find that they explain significant variation in expected returns. Furthermore, Bessembinder and Chan (1992) find that same types of economic variables[15] also possess some forecast ability in the futures markets. Bessembinder and Chan (1992) conclude: "Our results suggest that the forecast abilities of these instrumental variables is robust across markets, reinforcing the belief that they reflect the conditioning information set used by investors."

These studies generally suggest that there exist some general macroeconomic variables that can be used in forecasting or capturing rational variation in expected returns on stocks, bonds and also on commodity futures. The studies that were started by the work of Fama and French (1989) have generally noted that the required returns that investors demand vary over the business cycle.[16] The findings are that as the business cycle is in the upbeat and the economy is doing well, investors' required returns are lower and vice versa.

It is of uttermost importance to understand the nature and origins of asset return predictability when attempting to build a theoretical model of expected behaviour of asset returns.[17] The economic state variables behind the time-series behaviour of expected returns and risk premia are still unclear to the finance community, but the financial variables that have been argued to vary with business conditions or monetary policy and that have possessed significant forecast

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[14] The reason for calling the three variables business condition proxies is that Fama and French (1989) observed a relationship between the three variables and the business cycles identified by the National Bureau of Economic Research (NBER). Hence, they argued that the variables and then the variation in expected returns on stocks and bonds are related to business conditions which has been confirmed by separate analysis (see e.g. Chen (1991)).

[15] The economic variables used by Bessembinder and Chan were BAA-AAA which is the difference between Baa and Aaa -ranked bonds' yields, DIVYLD which is equity dividend yield, and BIL3YLD, a three-month Treasury bill yield.

[16] Fama and French (1989) were not the first ones to report forecastability of returns on common variables but what was unique was their contribution of linking the forecast variables to the real economy and their suggestion that the predictability is rational. Hence, strictly speaking Fama and French (1989) were not the first ones to tackle the issue of predictability

[17] There is also research on asset return predictability that creates problems for interpretation. It is hardly enough to show that a variable contained in time t's information set can help predict asset returns at time $t + k$. For instance, Yuan, et al. (2001) show that stock returns are lower on days around a full moon, essentially arguing that an almost completely unrelated variable (at least it seems that way to me) predicts returns on stocks. However, a theoretical model of asset return predictability requires that we understand the nature, characteristics, and origins of asset returns and risk premia, that is, the economic state variables behind the time-series behavior of expected asset returns (Patelis 1997).

power, could be thought to be related to the unknown economic state variables.[18] Many of the variables that researchers have found to be good predictors of asset returns could also be interpreted theoretically as indicators of the underlying macroeconomy (Patelis 1997). As an example, Estrella and Hardouvelis (1991) found the term structure of interest rates to be a significant predictor of real economic activity and as has been discussed, different interest rate spreads have been shown to predict stock and bond returns.

Fama (1991) discusses the extensive literature on asset return predictability and ponders upon the question whether the predictability reflects rational variation through time in expected returns or just irrational deviations of price from fundamental value. The suggestions of Fama and French (1989) are that there are systematic patterns in the variation of expected returns through time, which implies it is rational when coupled with the fact that it is common across stocks and bonds. The general message of the findings of Fama and French (1989) is that persistent poor times may signal low wealth and higher risk in securities increasing expected returns, or if poor times are expected to be partly temporary, expected returns can be high because consumers attempt to smooth consumption from the future to the present.[19]

The central question of this thesis is to see whether the predictable variation truly is common across markets and examine the return forecastability of commodity futures. If it is not, then an investor should change the allocation between commodity futures and traditional assets to obtain more favourable returns on the investment portfolio. Moreover, issues like market segmentation and nonparticipation[20] by some investors on commodity futures markets could lead to different impacts of the forecast variables on expected returns in the commodity futures markets and traditional asset markets.[21]

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[18] Chen (1991) finds that one origin of asset return predictability is the fact that state variables such as default spread and term spread are indicators of recent and future economic growth. Hence, he interprets the ability of the variables to forecast future market returns in terms of their correlations with the macroeconomic environment. Chen (1991, 553) concludes that the collective evidence relates the forecast ability of the variables on the market premium to their ability to forecast recent and future growth of the economy.

[19] Fama and French argued that two of the forecast variables (dividend yield and the default spread) forecasted high expected returns when times had been poor and growth rates of output had been persistently low and one variable (the term spread) forecasted high returns when the future rate of output growth were high. Moreover, Fama comments on the findings (1991, 1584-1584): "Finally, Fama and French (1989) argue that the variation in the expected returns on bonds and stocks captured by their forecasting variables is consistent with the modern intertemporal asset pricing models (e.g. Lucas (1978), Breeden (1979)), as well as with the original consumption-smoothing stories of Friedman (1957) and Modigliani and Brumberg (1955)."

[20] Theoretical models of commodity futures price bias incorporating these issues were discussed in the previous chapter.

[21] This might be possible since the market actors would not have homogeneous preferences or tastes for current versus future consumption (or whatever the underlying factor causing the rational variation).

3.2 Fama and French (1989) and the Implications to This Study

The findings of Fama and French (1989) were that expected excess returns (returns net of the one-month Treasury bill rate) on corporate bonds and stocks move together and can be forecast using common variables. Furthermore, the authors concluded that the variables used in forecasting were closely related to business conditions and the business cycle identified by the National Bureau of Economic Research (NBER). These results have been supported and complimented by many later studies.

The dividend yield (D/P) used in the research of Fama and French was found to relate to long-term business episodes that span several measured business cycles. The contribution of Fama and French was the observation that also bonds are closely tied to changes in the dividend yield. The intuition of the efficient-markets version of the hypothesis that dividend yields forecast stock returns is that stock prices are low in relation to dividends when discount rates and expected returns are at high levels, and hence D/P varies with expected returns. In summary, the novel result of Fama and French was that D/P is closely related to business conditions and that it can also be used to forecast bond returns.

A second variable used in the study was the default-premium (also called default spread) that was defined to be the difference between the yield on a market portfolio of corporate bonds and the yield on Aaa bonds. The default spread is consistently high during periods of persistent weakness in the economy and low when the business is blooming. Fama and French found that the default spread forecasts high returns on stocks and bonds when business conditions are persistently weak and low returns when business conditions are peaking out. In conclusion, the findings of Fama and French implied that the default spread and the dividend yield are very closely related to longer-term business conditions and are adequate for forecasting stock and bond returns.

The third variable used in the study was the term spread. The term spread was identified as the difference between the Aaa yield and the one-month T-bill rate. The findings were that the term spread was most closely of the three variables related to shorter-term business cycles identified by the NBER. The term spread and the component of expected return that it tracks were found to be low around measured business-cycle peaks and high near troughs. The logic behind this is explained in Fama (1988). He argued that the business-cycle variation in short-term interest rates is a mean-reverting tendency, which implies that the variation in long-term rates is significantly less extreme. Hence, the Aaa yield rises less than the bill rate during expansions and falls less when business is contracting. This leads to the clear business-cycle pattern of the term spread. The hypothesis that had been laid out before the findings of Fama and French was that the term premium compensates for exposure to discount rate shocks that affect all long-term securities and hence it impacts both bond and stock returns. The biggest contribution of Fama and French (1989) regarding the use of the term premium was the finding of the clear link between business conditions and the term variable.

Three major questions arise from the findings of Fama and French. First, what is the explanation behind the implicit relationship between investors' expected returns and business cycles? Second, what economic forces drive the economy between the observed business cycles, the longer- and shorter-term variability in the state of the economy? This is a question of macroeconomics and might be needed to answer the first question (Fama and French 1989). Third, can the observed predictability of expected returns be exploited to create superior investment strategies?

The story given by Fama and French that attempts to explain the first question is intuitively quite compelling. They suggest that when business conditions are poor, income is at low levels and expected returns must be higher to induce substitution from consumption to investment. When times are good, the reversal takes place, and higher income leads to the market clear at lower levels of expected returns.

This study attempts to utilize the findings of Fama and French and the followers to answer the third question. What could be an investment class that would complement the space of stocks and bonds and not follow exactly the same pattern of variation in expected returns? My suggestion is that commodity futures may provide investors with expected returns in excess of those provided by stocks and bonds during business cycle peaks. The intuition behind this idea is that excess returns in commodity futures should act contradictive to stocks and bonds in the different phases of the business cycle. The motivation for this idea comes from the observed variability through time in the normal backwardation of excess returns on commodity futures and the practitioner-oriented view of excess returns on commodity futures being driven by more near-term economic conditions than bonds and stocks, which can be seen as the underlying reason behind the often observed negative correlation between commodity futures and the more traditional investments.

Academic research has identified a negative correlation between commodity futures and the more common stocks and bonds. My argument is that this negative correlation is based on fundamental economics and is likely to be driven partly by the business conditions. While equity and bond valuations depend heavily on future expectations, the excess returns on commodity futures are more likely to be driven by short-term economic conditions that will at certain situations create increased hedging pressure, which will cause the normal backwardation to persist.

In other words, commodity futures and especially the front-end month contracts may perform very differently from equities and bonds during periods in which the near-term reality and future expectations diverge significantly. The two most obvious examples of such periods are the extremes of the business cycle. The depths of a recession, when near-term conditions are clearly bad, are the times when commodity markets would be expected to perform poorly and there would not most likely be hedging pressure that would cause short hedgers to compensate the speculators for taking the opposite positions in the back-end of the curve or consumers who would make the front-end of the futures curve to rise sharply. In stark contrast, declining interest rates and building expectations for renewed growth and better earnings would generate strong equity and bond markets. The D/P and default premium variables of Fama and French would probably be at high levels and thus the expected returns on stocks and bonds would be high. According to the logic, the opposite should happen during times when business is strong.

However, in attempting to create an asset allocation strategy that would exploit the variation in expected returns, I will use monetary policy and the Fed discount rate changes in making an easily implementable trading strategy that would utilize the apparent relationship between business conditions and variation in expected returns. This is motivated by more recent academic research on the impact of the monetary sector on security returns and the rhetoric question of Fama and French in their conclusion where they suggest that government monetary policy may be one of the driving forces in separating good times from bad in terms of business conditions. Furthermore, the empirical part of this study shows that monetary policy seems to be inevitably better in explaining expected returns on commodity futures, as has also been the case for equities in more recent asset return predictability research.

The variation in the expected returns of stocks and bonds depending on business conditions has been discovered in previous studies after Fama and French (1989). However, the relationship between excess returns in commodity futures and business conditions still remains open. This study will not attempt to fully uncover the relationship between commodity futures and business conditions, but rather attempt to follow the footsteps of Fama and French in examining predictable variation with variables used by them and also with variables used by other researchers inspired by the work of Fama and French.

3.3 Asset Return Predictability and the Role of Monetary Policy

Rozeff (1974) found in one of the early examinations of the association between equity market returns and monetary policy that a substantial fraction of the stock return variation is related to monetary policy and contemporaneous monetary developments. In a later study, he further suggests (Rozeff 1975):

> *While few propositions about the stock market are universally accepted, most members of the financial community probably agree that changes in Federal Reserve Board monetary policy strongly influence changes in stock prices.*

As the early findings of Rozeff (1975) suggest, among the burgeoning number of different equity market determinants, market participants do pay close attention to strategies based on the stance of the Federal Reserve monetary policy. There are indeed several empirical studies that suggest that changes in different indicators of central bank policy correlate with both short- and long-run stock market performance. For example, Fama (1981), Geske and Roll (1983), and Kaul (1987) present further evidence linking the monetary sector to the stock market.

There are numerous purported monetary policy transmission mechanisms that link the changes in the monetary environment or central bank monetary stance to the stock market, which in turn impacts aggregate output through investment effect and consumer expenditure

(Durham 2000). For example, one mechanism suggested by Modigliani (1971) proposes that a decrease in interest rates will raise stock prices and thus increase financial wealth and lifetime resources. The latter will raise consumption through the wealth effect according to this rationale (Modigliani 1971). These structural models create a voluminous research agenda. I will only concentrate and utilize the research on the first phase of the transmission, but a more complete picture of the relationship between long-run performances of the stock and bond markets could be formed with an understanding of the second phase effects.

The empirical relation between central bank policy and stock market returns is important in two different contexts in the study of financial and monetary economics. Firstly, the question addresses the extensive literature on stock market performance and has obvious implications for financial practitioners. Secondly, the question is also germane to central bankers and the study of monetary policy transmission mechanisms in which equity markets are a key structural link. (Durham 2000) Both of these reasons have inspired academic research on this topic and the latest innovations have concentrated on examining long-run international stock market performances and monetary policy and monetary indicators that investors know ex ante, so that the results could conceivably be replicated by investors.

To build a theoretical model of expected asset return behaviour, it is essential to understand the nature and origins of asset return predictability and to attempt to uncover the economic state variables behind the time-series behaviour of expected asset returns and risk premia. A good predictor of asset returns could likely be interpreted as an indicator of the underlying macroeconomy. These ideas motivate the use of monetary policy as a predictor of asset returns, since monetary policy can be argued to represent the economic conditions.

The research conducted on monetary policy and expected returns on stocks and bonds is closely related to the research done on the impact of the business conditions lead by Eugene Fama and Kenneth R. French. Jensen et al. (1996) combined the previously used business cycle proxies with a measure of monetary policy and found that the impact of the business condition proxies varies significantly across monetary environments. Hence, it seems that monetary policy may predict expected returns through or separately from the business conditions. Patelis (1997) uses monetary policy indicators in predicting excess stock returns and establishes the empirical fact that monetary policy indicators are significant predictors of excess stock returns capturing predictable variation in expected returns on stocks and bonds.

However, one complication in this discussion is the still prevailing debate between macroeconomists, whether monetary shocks have real effects. If we assume that they do, it can easily be extended that as monetary policy affects the real economy, then it should also affect equities, as they are claims on future output of companies. Patelis (1997, p.1953) suggests that "Obviously, we cannot expect monetary policy to fully account for the observed asset return predictability. Still, this appears to be a natural starting point in the examination of the source and nature of time-varying expected returns." There is also strong intuition that suggests that commodity futures returns should vary with changes in the real economy, if we consider price spikes coming with tighter inventories of for example energy or metals and the changes in consumption of the commodity due to stronger economic activity, or the impact of inflation on the behaviour of the agents acting in the commodity market.

What are the implications of the results of rational time-varying expected returns conditional on monetary policy to this study? First, the examination of variation in expected commodity futures returns dependent on monetary policy becomes as a natural extension to the research examining the predictability in the other asset markets. Second, since actual and expected inflation are undoubtedly important dimensions of monetary policy, the stringency of monetary policy may impact and could possibly be used in explaining variation in expected returns on commodity futures. Third, if monetary policy explains variation in expected returns on stocks, bonds and commodity futures that moves in different directions, this would imply that it may be possible to achieve more efficient allocations between stocks, bonds, and commodity futures depending on the state of the monetary policy. This would then imply that the incorporation of commodity futures into portfolios that take advantage of the variation in expected returns of different asset classes might create superior trading performances.

3.4 Discount Rate Changes

It is widely recognized that Federal Reserve policy has significant influence on security returns and that financial markets respond quickly to changes in the discount rate.[22] The first indications of this were found in studies concentrating on short-run discount rate change effects. For example, Waud (1970) found that discount rate decreases (increases) produce

[22] Discount rate is determined in Howells and Bain (1998, p.162) as the "rate charged by the Federal Reserve on short-term lending to depository institutions."

positive (negative) stock market reactions. Brown (1981) found that discount rate changes have an announcement effect on the foreign exchange market. Furthermore, studies by Smirlock and Yawitz (1985) and Pearce and Roley (1985) provide evidence that discount rate changes have an effect on the financial markets by studying the announcement effects of discount rate changes. Although in the context of this study the long-run implications of discount rate changes are of greater interest than mere short-run effects, these studies do nevertheless reveal that there exists an indirect link between the Federal Reserve discount rate setting and the returns on securities.

Jensen and Johnson (1995) state that financial markets focus on discount rate changes because they are viewed as indicators of future Fed policy. Furthermore, Jensen et al. (1996) provide direct evidence linking monetary policy and discount rate changes to long-run security returns, which is consistent with the results from the studies evidencing an indirect link as mentioned above. The results from empirical studies suggest that the view of some economists that the discount rate is the weakest monetary policy tool and merely an appendage is faulty if not totally wrong. Waud (1970, p.231) argues that discount rate changes affect market participants' expectations about the future course of monetary policy because

1. discount rate changes are made only at substantial intervals
2. discount rate changes represent a somewhat discontinuous instrument of monetary policy
3. discount rate changes are established by a public body perceived as being competent to judge the economy's cash and credit needs competently.

The reason for bringing up the discount rate as one main indicator of monetary policy is the key role that it plays in later parts of this study. Various academics have acknowledged the importance of the discount rate in determining the central bank monetary stance, which obviously reflects the monetary policy and thus also the prevailing macroeconomic conditions. The discount rate, and especially the direction towards which it is moving, will be used in determining two different monetary environments and thus two different macroeconomic states with respect to monetary policy, which are employed in the empirical part of this thesis.

More recently the asset return predictability research has concentrated on the forecast power of variables that can be seen as belonging to the monetary sector, as discussed in the earlier section. Some of the most successful variables in capturing predictable variation in expected returns of stocks and bonds have been different discount-rate variables representing the stance of the Federal Reserve monetary policy, essentially differentiating between expansive and restrictive monetary environments. The studies of Jensen et al. (1996, 1997, 1998) use a dummy variable that differentiates increasing and decreasing discount-rate-change series thus differentiating restrictive and expansive monetary policy periods. For instance, Jensen et al. (1996) find that expected stock returns are significantly greater during expansive monetary periods than in decreasing periods, using a data set from the United States covering the period from 1962 to 1991. A similar variable is used by Booth and Booth (1997) who find that the direction of the discount rate captures significant variation in expected returns of small cap stock, large cap stock, and bond portfolios. These findings suggest that the monetary stance of the Federal Reserve affects the long-run expected returns on stocks and bonds.

Interesting extensions to the analyses presented above have been made by studying the relations between expected returns and the discount rate in an international context and also by Jensen et al. (2000) whose results suggest that discount rates may also differentiate returns in the context of commodity futures.[23] Conover et al. (1999a, 1999b) analyse the relationship between expected returns and the stance of the monetary policy in international markets reporting evidence that the general relation holds in 12 of 16 cases during the study period starting from January 1956 through December 1995. The implication of the results is that an investor should purchase (sell) stocks in countries where the central bank's monetary stance is expansive (restrictive) (Conover et al. 1999b). The studies by Conover et al. (1999a, 1999b) also find that stock prices tend to be higher (lower) during periods of decreasing (increasing) discount-rate-change series by the Federal Reserve. Durham (2000) conducts sensitivity analyses on long-run international data and, contrary to the results of many others, suggests that the implications of his study to traders are that "perhaps monetary policy changes represent a 'vanishing anomaly,' as either monetary authorities have more clearly signaled policy changes, or market participants have more accurately anticipated policy movements."

[23] The results of Jensen, et al. (2000) are not conducted by the normal regression analysis approach as has conventionally been the case in the return predictability research, and cannot as such be interpreted as supporting or evidencing rational variation in expected returns in commodity futures.

In general, the evidence on the predictive power of the central banks' monetary policy is an interesting addition to the stock return literature. Even though the strength of the discount rate as a monetary policy tool has been sometimes criticized and questioned as having no effect, it has been shown to have strong forecast power on expected returns across international markets. The most appealing quality of the discount rate as a source of predictability is how it has clear implications to traders, even though questioned by Durham (2000). This study is partly an addition to this branch of the asset return predictability literature.

3.5 The Determination of Interest Rates

As became evident in the preceding sections of this chapter, interest rates as determinants of monetary policy or business conditions have been shown to possess forecast power in the determination of returns on different assets. To be able to address the issue of forecast power of interest rates, it is imperative to understand how interest rates are determined, which factors affect them and what is the role of the central bank in the determination of the interest rate and monetary environment. Furthermore, understanding the determination of interest rates helps in knowing what the information content embedded in different interest rate variables includes.

The rate of interest can be understood as a payment from borrowers to lenders compensating the latter for parting with funds for a period of time at some specific risk. Lenders are encouraged to forego consumption now in return for later consumption. In compensating savers for parting with funds, a rate of interest is rewarding savers for giving up the ability to consume if they should change their minds about saving. The rationale for saving and thus foregoing consumption is that people wish to provide for old age or future periods of zero income and hence the real rates of interest may be even negative. (Howells and Bain 1998)

The real rate of interest is the return that lenders require even if the loan contained no risk and prices were constant. The real rate of interest is the return for purely giving up the ability to spend. In contrast, nominal interest rates are the rates of interest that are actually paid. Howells and Bain (1998, p.46) describe nominal interest rates as consisting of four elements:

$$i = r + \pi + l + \sigma \qquad (12)$$

where r is the real rate of interest, π is an inflation premium, l is a liquidity premium, and σ is a premium for bearing risk. The inflation premium is the compensation for price rises that lenders expect to occur during the duration of the loan. It is also generally assumed that lenders prefer to lend for the shortest possible period and hence the long-term real interest rates will be higher than the short-term ones and the difference is described as the liquidity premium. Last, σ is a premium that is required to compensate the level of risk that is attached to the loan.

3.5.1 Market Theories of Interest Rate Determination

The short-term risk free interest rate is the starting point of the analysis of different interest rates. The nominal short-term risk free interest rate is composed of two elements, namely the real rate of interest and the inflation premium. There are two apparently conflicting accounts of how this basic rate is determined in the market, but what integrates them is the weight given to the role of private decision makers or so called market forces. The market theories of interest rate determination are discussed here and the next section presents the view that short-term rates are set by administrative decisions.

Two common accounts of the determination of interest rates are the loanable funds theory (LFT) and the liquidity preference theory (LPT). LFT is associated with the 'classical' economists of the Nineteenth and early Twentieth centuries and it explains the level of interest rates as the outcome of decisions between investing and saving (Howells and Bain 1998). The rate of interest is determined freely by the interaction of these two sets of decisions. In essence, the short-term risk free nominal interest rate is composed of a real rate determined by time preference and productivity of the economy plus a premium which reflects the expected rate of inflation often known as the Fisher effect. So the real rate of interest is:

$$r = i - \dot{P}^{e} \qquad (13)$$

where i is the nominal rate of interest and $\dot{P}^{e}$ is the ex ante (expected) rate of inflation. Equation 13 is often called the Fisher equation after the first systematic discussion of the relation between real and nominal rates by Irving Fisher's book, *Theories of Interest* (1930).

Fisher suggested that the real rate of interest tends to be stable over longer periods. After all, the real rate was explained as the result of time preference and capital productivity, and there is no reason to suppose that either of these would be subject to violent short-term fluctuations. He then argued the variations in the nominal rate to be a result of changes in the expected rate of inflation. Hence, the proposition that the nominal interest rate is a result of a stable real interest rate and a premium that follows closely the rate of inflation has become known as the Fisher effect. (Howells and Bain 1998)

Keynes attacked the loanable funds theory in his *General Theory of Employment, Interest and Money* (1936). Keynes explains the nominal interest rate as the result of an interaction between the supply and demand of money in liquidity preference theory. He argued that the demand for money depends upon the price level and upon the level of economic activity and it also depends upon the desire to hold money as a safe asset in an uncertain world. Furthermore, the degree of uncertainty that agents feel is variable, which leads to fluctuations in the demand for money and hence in the nominal rate of interest. One of the main assumptions in Keynes' model is that the supply of money is independent of the demand for it and it is fixed by monetary authorities (Howells and Bain 1998).

As becomes obvious when studying the LPT or LFT, neither one of them is satisfactory in explaining the determination of interest rates when considered alone. They are both based on rigorous assumptions that do not hold in the real world. They do, however, offer a starting point for analysing interest rate determination and especially the point of view of the Fisher effect becomes essential in this study as a link between interest rates and inflation, which become important through the observed link between inflation and excess returns on commodity futures. Next, the role of the central bank will be discovered in determining the prevailing interest rates.

3.5.2 The Role of the Central Bank

The discussion of the previous section emphasizes the role of private decision makers in determining short-term interest rates. However, in the real world it happens more than often that the media is reporting that monetary authorities have changed the level of official short-term rates or that financial markets speculate that the authorities will do that in near future. This raises questions concerning the validity of theories discussed in the preceding section.

The ability of central banks to exercise any influence over interest rates comes from their role as lenders of last resort. In essence, central banks act in monopoly roles in supplying liquidity in a general shortage of funds. A central bank can either decide the quantity of reserves made available and allow banks to bid for the available supply, or it can set the price and supply whatever quantity of reserves required. Whichever choice the central bank takes, it will determine short-term interest rates. This short-term rate sets the base to the level of interest rates, because commercial banks will not engage in lending at rates below the cost of the last resort. (Howells and Bain 1998)

Interest rate determination seems to have two conflicting economic theories, the market forces and the administrative setting by the central bank. Even though there is no straightforward theory that would completely and fully depict the situation, the theories come closer together when one acknowledges that there are a number of constraints set for the central bank and some of these constraints come from the market forces.

Central banks must in general set interest rates to levels that will be helpful in achieving a number of objectives. The main objective of many central banks is usually a low rate of inflation. However, even when there is a single overriding objective, there can be conflicting pressure on interest rates arising from conflict between different short, intermediate or long run objectives. It can also be argued that it is quite impossible for central banks to set interest rates that are not endorsed by the financial markets. Since capital can move almost without boundaries in today's global environment, it is hard for authorities to impose a level of short-term interest rates that is not considered appropriate by financial markets.

The conclusion that could be drawn from this discussion is that the setting of short-term interest rates depends upon both market forces, as implied by e.g. LFT and LPT theories, and upon monetary authority decisions. Central banks are often constrained by market sentiments but they do have an influence on short-term nominal interest rates at least in the short run, which may also yield influence over real rates.

3.5.3 The Structure of Interest Rates

There are a wide range of different financial instruments that are readily available for investors and the financing deficit units of the economy. They offer differing rates of return, but the minimum return that will be available is the risk free short-term nominal rate of interest, be it for example the return on a one-month T-bill. There is on top of the short-term interest rates a structure of longer dated rates. The structure is determined by lenders' willingness to hold assets which are not risk-free and short-term, relative to their supply. The two characteristics that affect demand of assets providing different interests are the term and risk of the asset. Hence, as term and risk increase, lenders are less willing to hold these assets and require premia to induce them to hold them.

The term structure of interest rates is the relationship between the yield and term to maturity of assets that are only different with respect to their terms to maturity. The term structure of interest rates is an interesting issue to finance and economics academics and practitioners since it may contain information about markets' perceptions of future interest rates. The implied future interest rates can be easily calculated using arbitrage arguments. Moreover, combined with the Fisher effect, the implied future interest rates from the term structure provide also implied inflation rates. In effect, market expectations of future short-term rates determine the relationship between current short and long rates, but what affects these expectations is a much more complicated question. One obvious source of changes in expectations are all the events that markets would think might cause a change in inflation. Hence, all effects one thinks would cause inflation to rise, would make the yield curve steepen (assuming higher inflation means higher interest rates, as the Fisher hypothesis suggests). (Howells and Bain 1998)

What are then the things that cause inflation or inflation expectations to rise? For instance, one important factor causing inflation expectations to rise would be higher than expected public sector borrowing. There is a strong acceptance in the financial community of the proposition that money-financed government debt causes inflation. However, the assessment by the market of the likely response of the monetary authorities to increasing government borrowing depends on the authorities' past anti-inflationary reputation. (Howells and Bain 1998) Supposing that the monetary authorities would have a strong reputation of being tough on inflation, an increase in government borrowing would be likely to cause a rise in the front-end of the yield curve without a subsequent effect in the long-end of the curve, the reason being that the market would not fear longer-term inflation.

This study still needs a short mentioning of the Federal Reserve inflation policy. In general, price stability is a central focus of the US monetary policy as explicitly informed in the Federal Reserve publications by for instance Saxton (1997) and Saxton (2000). This seems to be also in accordance with the market view of Federal Reserve's inflation stance. That would imply that monetary policy might be an interesting factor also in the determination of commodity futures returns since inflation is a core factor also in that context. Furthermore, Saxton (2000) states that commodity price indexes also serve as an important policy guide for the Fed, which is an implicit recognition of the relationship between commodities, inflation and monetary policy.

The reason for raising the term structure issue in this context is twofold. First, changes in the term structure of interest rates and also in the risk premium embedded in the interest rate structure have been used in academic studies discussed earlier in this thesis to predict asset returns. Second, changes in monetary policy and especially in inflation have been shown to impact returns on commodity futures, and the term structure contains information about the markets inflation expectations.

4 DATA DESCRIPTION, METHODOLOGY AND HYPOTHESES

4.1 Description of The Data

The investment returns data used in this analysis were obtained from the Datastream service and they cover the time period from 1.2.1987 until 1.2.2002. The data obtained from Datastream were modified into continuously compounded returns and the analyses employed monthly returns of the data used. Throughout this study, the merits of investing in the alternative asset classes are evaluated based on examination of the following indexes:

Traditional Portfolio:

Stocks: The Standard and Poor's S&P 500 Composite Total Return Index represented the performance of stocks in this study. It is often used as a proxy for the market portfolio of equities and therefore employed in this study.

Bonds: The Datastream Over 10 Year US Government Bond Total Return Index represents the performance of Treasury bonds over the period of examination in this study.

T-bills: Merrill Lynch 3 Month T-bill Total Return Index represents US Government T-bills in the analysis.

Commodity Futures:

GSCI: The Goldman Sachs Commodity Total Return Index (GSCI) is the return from a fully collateralized commodity futures investment and it is designed to be comparable to the return from an investment in a stock or bond index. Appendix 1 describes the GSCI more closely. The following commodity classes are sub-indexes of the GSCI.

Energy: Energy is one of the five sub-indexes of the GSCI. It has the largest weight in the GSCI and it has therefore the largest world-production of the commodity classes. It includes futures contracts for crude oil, Brent crude oil, unleaded gas, heating oil, gas oil, and natural gas.

Industrial Metals: Industrial metals include contracts for aluminum, copper, lead, nickel, and zinc. Industrial metals have the second smallest world-production weight of the five commodity classes.

Precious Metals: The precious metals group includes gold, platinum, and silver and it has the smallest world-production weight.

Agriculture: Agricultural products have the largest world-production after energy products. Agriculture includes wheat, red wheat, corn, soybeans, cotton, sugar, coffee, cocoa, and orange juice.

Livestock: The livestock commodity group includes live cattle, feeder cattle, and lean hogs.

The part of analysis that regresses the returns on commodity futures against the business condition or monetary variables employs excess returns. These were calculated by subtracting the one-month T-bill return from the total returns of commodity futures.

The three indexes that belong to the traditional portfolio could be considered as representatives of a conservative investment in the asset classes in which they belong. They were chosen on the basis that they were thought to represent the general performance of the asset classes in which they belong. The commodity futures investments that were chosen had a similar reasoning behind them. First, the GSCI is often described as the most standard commodity futures index. It has a world production weighting and it should thus describe the performance of commodity futures as a whole. The various commodity class investments are sub-indexes of the GSCI and thus represent the general performance of their respective commodity futures classes as an investment.

The length of the time-period investigated, 15 years, allows the use of reasonably robust statistics and therefore the study-period should give a good indication of the general performance of the different asset classes and be adequate for examining predictable variation in returns. The total amount of monthly observations in the study was 180.

The empirical section will also use various proxies for business conditions and monetary conditions. The data for them were obtained from the Datastream service and the data cover the period from 1.2.1987 until 1.2.2002.

Business Condition Proxies:

Dividend Yield (D/P):

The monthly data for the historical dividend yield cover the period from March 1987 to February 2002. The dividend yield in month T is calculated by summing the monthly dividends over months T – 11 through month T and then dividing the sum by the index value (P) which is calculated without dividend. The dividend yield used here is the S&P500 composite value-weighted index dividend yield.

Term Spread (TERM):

To calculate the term spread, the 10 year US Treasury middle rate yield and the bond equivalent US Treasury Bill rate were obtained from Datastream. To develop a measure of the TERM that would be similar to the ones used in the past academic research, I subtracted the contemporaneous 3-month T-bill return from the 10 year US Government bond return. This measure differs somewhat from the one used in Fama (1989) and Jensen et al. (1996) in that Jensen et al. used the difference between a 10- and 1-year US Treasury instead of using the T-bill and Fama and French (1989) had an all Aaa bond portfolio instead of a Treasury bond portfolio. On the other hand, Booth et al. (1997) use various long-term government bonds and the T-bill rate to define a measure for the term spread variable.

Default Spread (DEFAULT):

The default spread is measured here as the difference between the monthly average yields on an average 10-year US corporate bond rated Baa by Moody's and the 10-year Treasury bond. Both rates were obtained from Datastream. This measure is quite similar to the one used in Jensen et al. (1996) in which they define the default premium as the difference between a Baa corporate bond and the 10-year Treasury bond rates. Fama (1990) and Fama and French (1989) use the difference between a portfolio of all corporate bonds and the Aaa portfolio yield. Booth et al. (1997) use 20-year US Treasuries and Aaa and Aa-rated corporate bond portfolios. Finally, Schwert (1990) defined the default spread as the difference in yield between Baa and Aa-rated bonds.

Monetary Policy Indicators:

Federal Funds Rate (FFRATE):

The federal funds rate has been argued to be a good indicator of monetary policy actions because it is quite sensitive to shocks to the supply of bank reserves [Bernanke and Blinder (1992)]. Furthermore, Thorbecke and Alami (1992) and Thorbecke (1997) reported that the federal funds rate is a priced factor in arbitrage pricing theory (APT) model of stock returns. The federal funds rate is described in Howells and Bain (1998) as the "rate charged in the interbank market for lending between depository institutions." Patelis (1997) used the federal funds rate in capturing variation in stock returns.

Federal Funds Premium (FFPREM):

The federal funds premium is calculated as the difference between the federal funds rate and the three-month T-bill rate. Jensen et al. (1996) suggest that the federal funds premium serves as a broad indicator of monetary policy and hence it reflects changes in monetary stringency. It has not been used previously in return predictability literature.

Federal Funds Spread (FFSPR):

The federal funds spread is the spread between the federal funds rate and the yield on a ten-year Treasury bond. Patelis (1997) uses FFSPR in examining whether the stance in monetary policy can account for the observed variability in excess stock returns and his results imply that FFSPR can be used in explaining stock returns. Moreover, the use of FFSPR is also motivated by Bernanke and Blinder (1992) and Bernanke (1990) who use FFSPR to attempt to control for differences in the levels of inflation.

TABLE 1
Discount-Rate-Change Series during the Period of Study

This table shows the Federal Reserve discount-rate-change series from November 1984 to February 2002. A series is defined as a sequence of consecutive discount rate changes that are in the same direction. The study period starts from February 1987, hence the first series in the table has only seven monthly observations. The total number of monthly observations was 180, with 104 observations following rate decreases and 76 rate increases. The total number of rate changes during the study period was 41.

Rate Series: Increasing (I) or Decreasing (D)	First Rate Change in Series	Number of Rate Changes	Monthly observations
D	23/11/84	7	7
I	04/09/87	3	39
D	12/18/90	7	41
I	17/05/94	4	20
D	31/01/96	3	43
I	24/08/99	5	17
D	03/01/01	12	13

Source: Datastream.

Discount Rate Changes (DIR):

DIR is the directional discount rate change dummy variable. DIR takes a value of one if the previous rate change was an increase, and a value of zero if the previous discount rate change was a decrease. A DIR value of one indicates that a month falls into a restrictive monetary environment and a value of zero indicates that the monetary policy is expansive. The DIR variable will be used in dichotomising the sample period into restrictive and expansive environments. Since the DIR variable does not use future information in determining the monetary environment and it only uses past information in determining whether the variable gets a value of zero or one, it can be considered as an ex ante indicator. The variable will be used in both forecasting futures returns and in creating a trading scheme that differentiates expansive environments from restrictive ones. The use of the DIR variable is for example motivated by Jensen and Johnson (1995), Booth and Booth (1997), Jensen et al. (1997, 1998, 2000), and Conover et al, (1999a, 1999b) who showed that the DIR-indicator is a good, broad measure of monetary conditions. Discount rate is determined in Howells and Bain (1998, p.162) as the "rate charged by the Federal Reserve on short-term lending to depository institutions." Table 1 provides the details of the discount rate series during the period of study.

4.2 Methodology

I will first examine whether the selected business condition proxies or monetary policy variables can forecast expected returns on a rolling strategy in front-end month commodity futures, i.e. in the various subclasses of the GSCI. The variables used have been shown to possess forecast power in the stock and bond markets and hence they may also be utilized in forecasting predictable variation in commodity futures returns. The rolling strategy is represented by the sub-indexes of the Goldman Sachs Commodity Index.

The tests center on regressions of future excess returns of different commodity futures classes, $r(t,t+T)$, on a common set of variables, $X(t)$, known at time t,

$$r(t,t+T) = \alpha(T) + \beta(T)X(t) + \varepsilon(t,t+T) \tag{14}$$

In other words, this approach to asset return predictability testing regresses asset returns at a time horizon t + T on variables[24] contained in time t's information set. The excess return is calculated by subtracting the continuously compounded contemporary T-bill return from the total return on the continuously compounded collateralised futures investment.

The regressions only include economic variables that have been previously shown to possess forecast power on stocks, bonds or the real economy. It is clear that variables of this kind cannot forecast extremely accurately returns on commodity futures, as they have only contained relatively marginal forecast power on stocks and bonds as well. However, the contribution of finding any forecast power may be a contention of predictable and also rational variation in expected returns in some commodity futures classes. Fama (1991) argued that the forecast power, if rational, should be common across asset classes tracing back to changes in tastes or preferences and the state of the economy as such. Naturally, it would imply possibilities for enhanced macro-diversification if the changes in expected returns would move in different economic cycles across asset clases. Hence, it is one more

[24] The required properties of the variables and the testing procedures for stationarity are discussed in the later parts of this chapter in more detail. Furthermore, combinations of variables that have been employed in earlier studies will be used also here to avoid spurious regressions and excessive correlation of explanatory variables.

emphasized that the objective is not to find a perfect forecasting model[25], but to rather look for common predictable variation in expected returns that could be explained in the context of existing theory.

This first part of the research starts with an examination of the autocorrelations of the explanatory variables and the futures returns. Secondly, the evolution of the business condition proxies and monetary variables across NBER business cycles and monetary environments identified by the DIR indicator are examined graphically. Thirdly, the stationarity of the explanatory variables is examined. Fourthly, I will present results for the signs of the slope coefficients obtained in earlier research. Then, three sets of regressions are performed to examine the forecastability of the futures returns.[26] Finally, I will gather the signs of the slope coefficients obtained in regressions of this study in one table with results of earlier research for stocks and bonds, which will enable an examination of similarities or differences in the cycle of predictable variation. These issues concentrate on answering the primary research question and the subsections of 5.1. are devoted to this.

The second part of the empirical research concentrates on examining the attractiveness of commodity futures as an investment and the impact of monetary policy on investment decisions including commodity futures. The analytical framework that underlies the evaluation of the investment strategies presented in this study is known as mean-variance theory and it was initially devised by Harry Markowitz [Markowitz (1952)]. The theory assumes that investors are risk-averse and thus minimize the risk of the portfolio measured by the standard deviation of the portfolio return at all levels of risk. The formulation of the efficient portfolios is the following:

$$\text{Minimize} \quad \sum_{i,j=1}^{n} w_i w_j \sigma_{ij} \tag{15}$$

[25] First, this study attempts to use only forecast variables that are somehow linked to the state of the macroeconomy which gives them a scientific meaning and links them to finance theory. Second, the explanatory power of the previous models has not been very robust but statistically significant, which implies that a systematic relationship between return variation and economic variables exists, and the forecast variables are such that the variation can be argued to be not only systematic but also rational.

[26] The last set of regressions does not have precedents in finance research in the sense that the forecast variables used form a unique set. To be able to make inferences concerning the differences in forecast power between commodity futures and equities in this subset, the regressions are also reported for S&P500 in table7.

subject to $\sum_{i=1}^{n} w_i \bar{r}_i = \bar{r}$ (16)

$$\sum_{i=1}^{n} w_i = 1 \qquad (17)$$

, where

w_i for all $i = 1,2,...,n$ is the proportion of the portfolio allocated to asset i,

$\bar{r}_i$ for all $i = 1,2,...,n$ is the expected return of asset i,

σ_{ij} for all $i, j = 1,2,...,n$ is the covariance of assets i and j respectively, and

$\bar{r}$ is the required expected return of the portfolio by the investor.

This study will also add a third constraint, namely

$$w_i \geq 0 \text{ for all } i = 1,2,...,n \qquad (18)$$

meaning that no short-selling of assets is allowed.[27]

The calculation of the results will start by descriptive statistics. Secondly, I will test the significance of the correlations' deviations from zero. Thirdly, the examination of the role of commodity futures in optimal portfolios is done by using Markowitz portfolio optimization in constructing optimal portfolios both with and without commodity futures.[28]

Jensen, et al. (1996) showed that changes in monetary conditions are related to changes in the default and term premia. Their evidence suggested that investors alter their required risk premiums and inflation expectations according to changes in monetary stringency. Jensen, et al. (2000) note that the link between business conditions, inflation expectations and monetary policy suggests that monetary policy could also be linked to commodity futures returns in addition to the previously observed stock and bond returns.

[27] The reason for adding the constraint of no short-selling of assets is twofold. First, many previous studies have assumed no short-selling because they have wanted to replicate a passive and conservative strategy. Second, the underlying idea of adding commodity futures into the investment portfolio as a hedge against inflation assumes that one buys commodity futures to benefit from the returns during periods inflationary environment, and is essentially long in the contract.

[28] This methodology is also used in section 5.2.2 in which the attractiveness of commodity futures as a portfolio component is evaluated during periods of different monetary stringency. Section 5.2.1 attempts to find an answer to the secondary research question.

The examination of the investment strategy that utilizes the ex ante monetary stringency indicator, the directional DIR variable, will be done in section 5.2.2. as follows. The division of the study-period into expansive and restrictive monetary environments will be based on the binary classification used in for example Booth and Booth (1997), Jensen, Johnson and Mercer (1996, 1997, 2000) and Conover et al. (1999a, 1999b). These studies suggested that a binary classification technique is an adequate broad measure of monetary conditions. The classification will separate months of expansive and restrictive monetary environments depending on whether the latest change in the US discount rate was an increase or a decrease. In this study, the monetary environment is considered expansive (restrictive) if the latest discount rate change was a decrease (increase). The months in which a change occurred that was opposite to the previous change are left out since it would be impossible to classify them into either one environment. The total sample period (180 months) included six discount rate changes that lead to their respective months' exclusion of the analysis, because it would have been impossible to classify them as falling into only one of the monetary environment definitions. After the division, the study proceeds by examining commodity futures as an investment during expansive and restrictive periods much in the same way as was done with the full sample.

The most important and convenient quality of the measure of monetary stringency employed here is that it would have allowed investors to change their portfolio weights subsequent to the discount rate change in an ex ante manner and thus it would have yielded results that could have been replicated by investors. Furthermore, this division of monetary environments is supported by the previously mentioned studies.

After using the discount rate as the broad variable defining the stance of monetary policy, an attempt is made to validate its use as a broad economic indicator by examining how it relates to the variables used in previous studies. We dichotomize the sample period into expansive and restrictive periods and study the differences of the three business condition variables and the indicators of monetary policy used in the academic literature and in this study during expansive and restrictive periods by examining the variable means across monetary environments. This should give some indication of the validity of the monetary stringency indicator and enable more robust inferences regarding the nature of the results.

4.2.1 Nonstationary Processes and Unit Roots

Studies in empirical macroeconomics and finance often involve nonstationary and trending variables. Nonstationarity mandates a revision of the standard inference tools and one appropriate way to manipulate a nonstationary time series is to use differencing to reduce it to stationarity and then analyse the resulting series as vector autoregressions, VARs (Greene, 2000). This section will discuss some of the theory on time-series models that will be needed in the regressions of the empirical section of this study.

First, we require a definition for time series. Greene (2000) describes time series as a set of observations drawn on the same observational unit at a number of usually evenly spaced points in time. In other words, a time series can be understood as a sequence of successive observations which are realisations of identically distributed random variables. Underlying the realised observations is some data generated process, DGP, and the purpose is to find out what the DGP is.

Before moving on to the empirical regression section, it is important to define stationarity and nonstationarity to assure that we can make appropriate conclusions from the regressions following later. The need to understand and detect nonstationarity arises from the fact that if the time series are nonstationary, least squares estimators will be inconsistent and diagnostic statistics, such as t and F statistics, will not have their standard limiting distributions (Dougherty, 2002). The consequence is that, with nonstationary time series, the regression coefficient of an explanatory variable may apparently be significantly different from 0 when in fact it is not a determinant of the dependent variable.

A stationary series has a mean μ and a constant, finite variance. Furthermore, a time series X_t is weakly stationary if its expected value and population variance are independent of time and if the population covariance between its values at time t and time t + s depends on s but not on time t (Dougherty, 2002). The time series has a tendency to wonder around the attractor μ and any value far away from the mean is inclined to be followed by values close to the mean. Greene (2000) and Banerjee et al. (1993) define a stochastic process y_t as weakly stationary or covariance stationary if it has the following properties:

1. $E[y_t] = E[y_{t-s}] = \mu$
2. $E[(y_t - \mu)^2] = E[(y_{t-s} - \mu)^2] = \sigma_y^2 < \infty$
3. $E[(y_t - \mu)(y_{t-s} - \mu)] = E[(y_{t-j} - \mu)(y_{t-j-s} - \mu)] = \gamma_s$, for all t and s.

The equations above imply that $E[y_t]$ is independent of time t, $Var[y_t]$ is a finite constant independent of time t, and $Cov[y_t, y_s]$ is a finite function of t – s, but not of t or s, meaning that the covariance between observations in the series is not a function of the time at which the observations occur but instead a function of how far apart the observations are in time.[29] A stationary time series is also called a short-memory system since an old shock's effect to the system will fade away, and a shock will have virtually no effect if it happened a long time ago.

Now that a stationary time series is defined, it is important to find out what a nonstationary time series looks like and how it behaves. A simple example of a nonstationary process is the following AR(1) process or random walk in which the value at time t is defined by the preceding value plus an error term or innovation:

$$y_t = y_{t-1} + \varepsilon_t, \tag{19}$$

and by direct substitution the process becomes

$$y_t = y_{t-1} + \varepsilon_t = y_{t-2} + \varepsilon_{t-1} + \varepsilon_t = \ldots = y_0 + \varepsilon_1 + \varepsilon_2 + \ldots + \varepsilon_t. \tag{20}$$

Assuming that the error terms are identically and independently distributed with zero mean and boundary variance $(\varepsilon_t \sim i.i.d(0, \sigma_\varepsilon^2), \text{for all t})$, the process y_t will be a simple sum of random variables and the starting value y_0. Equation 20 shows that the current value of y_t becomes dependent on the starting value y_0 and the successive white noise terms. As the innovations are being generated by the same zero-mean, constant-variance distribution, then

[29] A time series is strong stationary if the whole probability distribution of the stochastic process is independent of time. Greene (2000) states that "*Strong* stationarity requires that the joint distribution of all sets of observations $(y_t, y_{t-1}, \ldots)$ be invariant to when the observations are made."

the variance of y_t will obviously become infinite as t grows (Greene, 2000). The variance can be defined as follows:

$$Var(y_t) = \sum_{i=1}^{t} Var(\varepsilon_i) = t\sigma_\varepsilon^2 \, , \tag{21}$$

which approaches infinity as t grows

$$\lim_{t\to\infty}[Var(y_t)] = \lim_{t\to\infty}\left(t\sigma_\varepsilon^2\right) \to \infty \, . \tag{22}$$

Hence, the variance of the series becomes dependent on the sample size and the point of time making the process nonstationary. The contribution of each innovation, or shock, as it is often described in this context, is permanently built into the time series. When the series incorporates the sum of the shocks, it is said to be integrated (Dougherty, 2002).

The random walk described above is clearly a nonstationary process. On the other hand, the first difference of y_t can be taken to induce stationarity. The first difference of y_t,

$$z_t = y_t - y_{t-1} = \varepsilon_t \, , \tag{23}$$

is simply the latest innovation which is assumed to be stationary by definition. Hence, the series y_t is said to be integrated of order one, denoted I(1), because a stationary process can be produced by taking the first difference of the series (Greene, 2000). And accordingly, a nonstationary series is integrated of order d, denoted I(d), if it becomes stationary after being differenced d times. To complete the logic, a stationary process needing no differencing is obviously I(0).

This section has discussed nonstationarity of variables in order to help understand the later parts of the study where detection and elimination of nonstationarity will become topical. The understanding of stationarity will be important to be able to make correct inferences from the empirical regressions. For instance, in the case of a model where the time series are nonstationary because they are subject to deterministic time trends, the risk of obtaining spurious results becomes evident.[30] Furthermore, to avoid making the wrong conclusions based on spurious regressions it is important to note that spurious regressions can arise in regressions using integrated time series, and even in regressions using stationary time series, if evidence of autocorrelation in the disturbance term is ignored (Dougherty, 2002). Hence, a close eye will have to be kept on the error term and it is important to observe possible low values of the Durbin-Watson statistic of the error term.

4.2.2 Detection of Nonstationarity

Many economic time series appear to be of the I(1) type, which makes it very important to assess whether a time series is nonstationary before attempting to use it in a regression model (Dougherty, 2002). Formal methods of detecting nonstationarity are often called "tests for unit roots" and the standard test for detecting a unit root is the Dickey-Fuller test. I will test for the presence of a unit root in the economic variables by using the modified formulation, the augmented Dickey-Fuller test, which has the advantage that it can accommodate higher-order autoregressive processes in ε_t (Greene, 2000). The augmented Dickey-Fuller test is carried out in the context of the model (Greene, 2000, p.783):

$$\Delta y_t = \mu + \gamma^* y_{t-1} + \sum_{j=1}^{p-1} \phi_j \Delta y_{t-j} + \varepsilon_t, \tag{24}$$

where

$$\phi_j = -\sum_{k=j+1}^{p} \gamma_k \tag{25}$$

and

$$\gamma^* = \left(\sum_{i=1}^{p} \gamma_i \right) - 1. \tag{26}$$

---

[30] If one supposes that a variable Y_t is regressed on another variable X_t, and both of them possess time trends but are not being directly related, the risk of obtaining spurious results rises. If the time trends give rise to a high sample correlation between the two variables, R^2 will be high because it is equal to the square of the correlation. As a result, the F statistic and the t statistic for the coefficient of X_t will also become high, despite the fact that X_t is not a determinant of Y_t. A simple solution is to the problem is to detrend the variables before performing the regression (Dougherty, 2002).

The test is carried out by testing $\gamma^* = 0$ against $\gamma^* < 0$, the null hypothesis meaning that a unit root is present and implying that differencing will be required.

There are also other procedures for detecting nonstationarity and the presence of a unit root has attracted a good deal of interest in statistical theory and application. Since other test procedures, intended to complement unit root tests such as the Dickey-Fuller test, are readily available with the help of modern programming tools[31], I will also employ two alternative tests to study the properties of the variables and to enhance the testing results. First, the Phillips-Perron unit root test for the null hypothesis that a unit root exists is employed [For reference, see for example Perron (1988), Phillips and Perron (1988) or Banerjee, et al. (1993)].[32] Second, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test will be calculated with the null hypothesis that the time series is I(0) or stationary [For reference, see for example Kwiatkowski, et al. (1992)].[33] These two tests combined with the augmented Dickey-Fuller test should indicate whether the economic variables that are used are stationary or not.

4.3 Hypotheses

The hypotheses of this thesis arise from the research questions and objectives of the study. The theory motivating them has been discussed in two earlier chapters and they are also laid out by the objectives of this study.

[31] The programming language used was R-language. The software is available at http://www.r-project.org/.

[32] The extensions to Dickey-Fuller tests made in the Phillips-Perron test concentrate on the power of the test statistic. Banerjee, et al. (1993, p.109) explain the modifications made to the test statistic, "That is, while the Dickey-Fuller procedure aims to retain the validity of tests based on white-noise errors in the regression model by ensuring that those errors are indeed white noise, the Phillips procedure acts instead to modify the statistics after estimation in order to take into account the effect that autocorrelated errors will have on the results."

[33] Kwiatkowski, et al. (1992) conclude that the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is used to complement unit root tests such as the Dickey-Fuller tests to distinguish series that appear to be stationary, series that appear to have a unit root, and series for which the data or the tests are not sufficiently informative to enable strong inferences of whether the series are stationary or integrated. Furthermore, Kwiatkowski, et al. (1992) point out that the main technical innovation of their study is the allowance made for error autocorrelation similar to the Phillips-Perron corrections for unit root tests.

The first hypothesis is associated with the question of return forecastability.

Hypothesis 1:[34,35]

H_0: The economic variables have no predictive power on commodity futures.

H_1: The economic variables do forecast returns on commodity futures significantly.

If H_0 is rejected in hypothesis 1, another question arises concerning the sign of the slope coefficients of the forecast variables. This is presented as hypothesis 2.

Hypothesis 2:

H_0: The forecast variables' slope coefficients have common signs across markets.

H_1: The signs of the forecast variables' slope coefficients differ across markets.

If the signs of the forecast variables' slope coefficients differ across markets, then it might be possible to create a trading strategy that capitalises on the differences in variation of expected returns across markets. This will not be presented as a hypothesis, but as already discussed, the empirical section will identify a simple trading strategy that utilizes only ex ante information to capitalise on the predictability in return variation. This part of the study is also closely linked to hypothesis 3.

Hypothesis 3 examines the investment performance of different commodity futures classes. It is motivated by the secondary research question.

Hypothesis 3:

H_0: No commodity futures class is attractive as a portfolio component.

H_1: The introduction of different commodity futures classes to the investment mix enhances the portfolio risk-return tradeoff.

---

[34] Alternative hypothesis would have H_0 of common forecastability across markets [the competing null hypothesis would be motivated by Fama and French (1989) and Fama (1991)].

[35] Since the study is quite unique and studies on commodity futures return forecastability using economic variables are scarce, there are no rigorous theoretical grounds or empirical suggestions that would enable me to create a hypothesis for the signs of slope coefficients or predictive power of each economic variable separately. Hence, hypothesis 1 and 2 are quite broad. However, the signs of the slope coefficients obtained for stocks and bonds are presented in section 5.1.4.

5 EMPIRICAL RESULTS

5.1 Forecasting Commodity Futures Returns

5.1.1 Autocorrelations

The autocorrelations of the variables that are used in forecasting returns should give information about the behaviour of expected returns, or more precisely of the component of variation in expected return that they track. Hence, I start the analysis following the footsteps of Fama and French (1989) who started with a glimpse on the autocorrelations. As can be seen from table 2, the autocorrelations of the explanatory variables are large at the first-order (yearly) lag but tend to decay over time. The business condition proxies are very autocorrelated but for default and term spreads there is some tendency towards mean reversion as was also suggested by Fama and French (1989). This phenomenon is especially noteworthy for the term spread that is strongly autocorrelated at the first-order lag, but where the autocorrelation diminishes relatively rapidly. The same notification as Fama and French made, that the component of expected return that the dividend yield tracks is very persistent, can be made here and the persistence is even stronger than that reported by Fama and French (1989). That is, the dividend yield reflects time variation in expected returns in response to economic states that tend to persist for longer periods. A natural question arises concerning the possible forecast power of the dividend yield on the returns of commodity futures, namely because commodities are often viewed as having a short sight to future contrary to stocks. Hence, if the dividend yield is a result of stock bubbles and not the underlying economic conditions or the economic variables that it tracks extend far away to future, then one could suspect that its forecast power on commodity futures would be void.

The autocorrelations of the monetary condition proxies are also very persistent, but still much less than that of the dividend yield. The federal funds premium is the least autocorrelated at the first-order lag, but does not decay as rapidly as the federal funds spread. The autocorrelation of the monetary variables becomes much weaker relatively rapidly, implying

TABLE 2

Autocorrelations of the Excess Returns and Economic Indicators

Summary statistics for monthly observations of one-month excess returns on five commodity futures classes, and the dividend yield (D/P), default spread (Default), term spread (Term), federal funds rate (FFRATE), federal funds spread (FFSPR), and federal funds premium (FFPRM).[a]

	Monthly Mean	S.D	Autocorrelation Monthly Lags 1	2	3	4	5	6
Excess Returns:								
Energy	0,464	8,686	0,164	0,011	0,065	-0,104	-0,083	0,122
Industrial Metals	0,506	6,815	0,085	-0,095	0,128	0,148	0,017	0,084
Livestock	0,117	3,782	-0,044	0,058	-0,04	0,044	0,14	0,171
Precious Metals	-0,522	3,368	-0,102	-0,087	-0,014	-0,038	-0,039	-0,137
Agricultural	-0,456	4,382	-0,071	-0,03	0,035	0,052	0,047	0,018
GSCI	0,217	4,996	0,122	0,047	0,075	-0,041	0,018	0,189

	Monthly Mean	S.D	Autocorrelation Yearly Lags 0,5	1	1,5	2	2,5	3
Business Condition Proxies:								
D/P	2,364	0,800	0,931	0,846	0,754	0,663	0,56	0,446
Default	1,838	0,466	0,592	0,38	0,284	0,257	0,224	0,166
Term	1,658	1,298	0,774	0,436	0,187	0,027	-0,138	-0,252
Monetary Condition Proxies:								
FFRATE	5,611	1,802	0,781	0,52	0,318	0,134	-0,052	-0,210
FFSPR	1,368	1,452	0,774	0,454	0,232	0,079	-0,098	-0,263
FFPREM	0,293	0,317	0,533	0,455	0,329	0,275	0,124	0,009

[a]Monthly excess returns are differences between the continuously compounded total returns less the one-month T-bill rate, or the returns on uncollateralized futures. D/P is the ratio of S&P500 value-weighted index dividends for the past year to the value of the portfolio at year-end. Default is the difference between the yields of a ten-year Baa-rated corporate bond and a ten-year treasury bond. Term is the difference between the ten-year Treasury bond yield and the three-month T-bill yield. FFRATE is the federal funds rate, and FFSPR is the spread between the federal funds rate and the yield on the ten-year Treasury bond. FFPREM is the difference between the federal funds rate and the three-month Treasury bill rate. In later regressions, the explanatory variables, business condition and monetary condition proxies, are lagged by one-month relative to the excess returns.

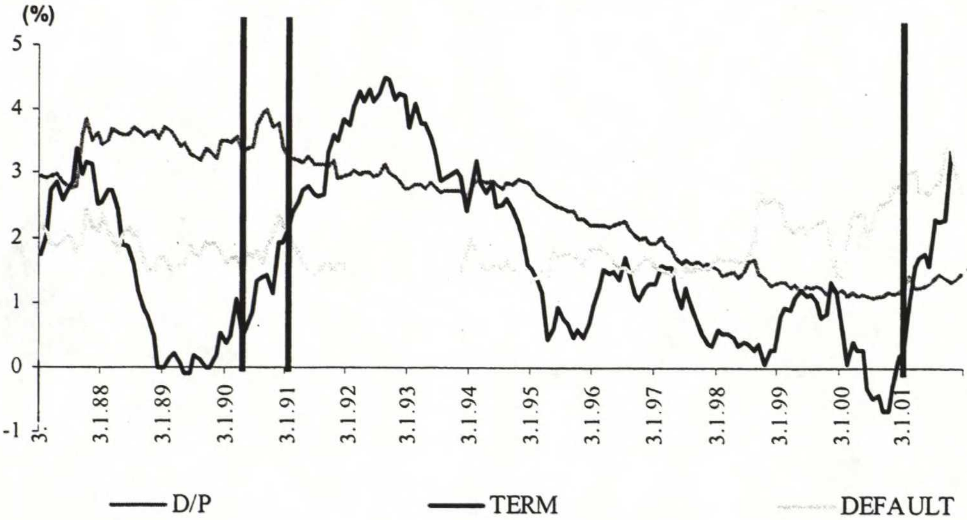
that also the monetary condition variables reflect more contemporary developments in the economy, giving the implicit result that they may prove valuable in forecasting commodity futures that would intuitively depend on contemporary events and conditions.

5.1.2 Plots of the Forecasting Variables

Since the variation of expected returns is measured by linear regressions of the returns on the forecasting variables, the plots of the forecasting variables can be used to examine the components of expected returns that they possibly track.

FIGURE 3
Business Condition Proxies and the NBER Business Cycle

Figure 2 depicts the variation in the monthly values of the value-weighted dividend yield (D/P), default spread (DEFAULT), and term spread variables (TERM)[a]. The three vertical lines are the National Bureau of Economic Research (NBER) business cycles identified for the study period from 1987 to 2002. The two peaks identified by NBER are the peak of July 1990 and the peak of March 2001. The only business cycle trough was identified by NBER at March 1991.



[a]The economic variables examined are the dividend yield on the value-weighted S&P500 composite index [D/P], the term spread which is the difference between the yield on a ten-year Treasury bond and a three-month T-bill [TERM] and the default spread which is the difference between a ten-year Baa-rated corporate bond and a ten-year Treasury bond [DEFAULT]

Figure 3 provides the first picture of the three variables that have been argued to represent the economic business cycles. This is, however, difficult to note from the period of data used in this study, since the period of study includes only two peaks of the business cycle and one trough as identified by the National Bureau of Economic Research (NBER). Hence, the length of the period of study does not enable any strong inference with graphical examination concerning the link of the three variables and the business cycles. Furthermore, the length of the study period (15 years) will not be likely to give results that would be as indicative as those of some of the earlier studies done on only stocks and bonds, in which the periods of study have extended all the way back to the period of the Great Depression or the post World War II era.

Fama and French (1989) noted that the Term variable has a tendency to rise near troughs and fall near business cycle peaks. A similar type of pattern can be observed during the period of this study, as the Term has its lowest values close to the peaks of July 1990 and March 2001 and it rises consistently through the business cycle trough of March 1991. The Default spread and the dividend yield variable have been argued to display similar although more persistent

FIGURE 4
Business Condition Proxies and Monetary Stringency

Figure 4 depicts the variation in the monthly values of the value-weighted dividend yield (D/P), default spread (DEFAULT), and term spread (TERM) variables[a] over the expansive and restrictive (shaded) monetary policy periods during the period of study 1987-2002. Monetary policy is defined expansive (restrictive) by the directional rate-change dummy variable DIR if that the latest change in the Federal Reserve's discount rate was a(n) decrease (increase). Table 1 provides the dates for the monetary periods.

[a]The economic variables examined are the dividend yield on the value-weighted S&P500 composite index [D/P], the term spread which is the difference between the yield on a ten-year Treasury bond and a three-month T-bill [TERM] and the default spread which is the difference between a ten-year Baa-rated corporate bond and a ten-year Treasury bond [DEFAULT].

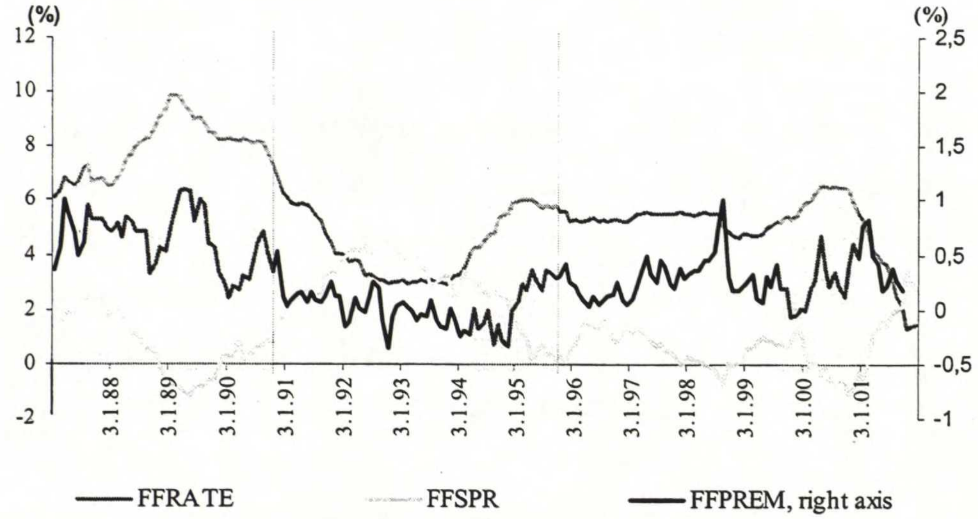
patterns [see for instance Fama and French (1989)]. However, during the period of this study, strong conclusions concerning this phenomenon cannot be made with graphical examination.

The reasons for the weaker performance patterns of the Term spread, Default spread and the D/P variables than what has been reported in previous research may be twofold. Firstly, the period of study is considerably shorter than that of many predecessors, for instance, Fama and French (1989) had a study period of 60 years in contrast to 15 years used in this study. Secondly, it could be argued that the end of the previous millennium was not the most typical of times and that the apparent relation between the proxies and the business conditions broke down somewhat from the typical historical pattern. Furthermore, the small amount of business cycles during the study period obviously makes strong conclusions and inference impossible in a graphical examination.

FIGURE 5

Monetary Variables Across Periods of Different Monetary Stringency

Figure 5 depicts the variation in the monthly values of the federal funds rate (FFRATE), federal funds spread (FFSPR), and federal funds premium (FFPREM) variables[a] over the expansive and restrictive (shaded) monetary policy periods during the period of study 1987-2002. Monetary policy is defined expansive (restrictive) by the directional rate-change dummy variable DIR if that the latest change in the Federal Reserve's discount rate was a(n) decrease (increase). Table 1 provides the dates for the monetary periods.



[a]The economic variables examined are the federal funds rate [FFRATE], the federal funds spread which is the spread between the yield on a ten-year Treasury bond and the federal funds rate [FFSPR], and the federal funds premium which is the difference between the federal funds rate and the three-month T-bill rate [FFPREM].

In figure 4, the three forecasting variables are depicted against the directional dummy variable, DIR, that has been argued to be a crude variable differentiating two different environments of monetary stringency. Jensen et al. (1996) argue that the Term, Default, and D/P variables display cyclical variation that varies with the DIR variable. The same observation can be made here for the Term variable. The Term variable is smaller after every increasing rate series, that is, after every restrictive monetary environment. The Default variable tends to show the same type of tendency but to a considerably smaller extent. It is somewhat weaker than that displayed by the Term spread, and the last period of restrictive policy did in fact experience an increase in the default spread. However, in the case of the dividend yield, no clear pattern is associated with changes in monetary policy. The conclusions from examining the dividend yield could be that it in fact does capture some type of more persistent-pattern business cycle, which is blurred by the too short sample period used in this study. The persistence in this pattern would then overlap business cycles and different monetary environments.

There is, however, another possible explanation for the behaviour of the dividend yield, which would imply that it in fact does not relate to business cycles or underlying economic state variables. Patelis (1997) argues that one reason why a low dividend yield predicts low stock returns is that, if one accepts the possibility of irrational bubbles, then a low dividend yield signals too high stock prices, which will eventually lead to the burst of the bubble and lower stock prices. This explanation may seem reasonable considering the experiences from stock markets during the past years.

The plots of the business condition proxies show especially that the Term could be argued to vary with the business cycle and also depending on the stringency of the monetary policy as captured by the DIR variable. These observations are closely in line with earlier research. Moreover, it was noted that the D/P and Default variables do not apparently possess a similar shorter-term cyclical nature and for reasons of a relatively short study period of 15 years, very strong inference cannot be made regarding their variability with the economy. In contrast, the very low dividend yields preceding the burst of the stock market bubble close to the turn of the millennium imply that the suggestions made by Patelis (1997) questioning the relation of the dividend yield and economic factors may be well in place. In fact Patelis (1997) argued that whatever the source of stock return predictability, it should be reflected by the dividend yield, which would then act as a test of model misspecification in the regressions.[36]

The observation that the term varies closely with the monetary conditions is in line with the findings of Jensen et al. (1996) who also argued that the default variable and to a smaller extent dividend yield do perform similar variation. The term and default variables tend to bottom out during periods of increasing discount rates and increase higher during decreasing rate series. Moreover, Jensen et al. (1996) note that "The transition from increasing to decreasing rate-change periods should generally happen near the end of economic expansions, though the Fed is often shown, ex post, to continue increasing rates into economic slowdowns." This observation links informally together the business conditions and monetary stance of the Federal Reserve.

Figure 5 depicts the monetary variables across the different rate-change series. As is clearly observable, the Federal funds rate varies closely in line with directional rate-change dummy.

[36]Patelis (1997, p. 1956) argues using a "dynamic Gordon dividend model" that whatever the sources of stock return predictability, the dividend yield will reflect them. He then interprets the predictive power of the dividend

Bernanke and Blinder (1992) argue that the FFSPR variable is an indicator of monetary policy, carrying information on inflationary expectations by the long-term bond yield which is insensitive to short-term shocks to monetary policy that are captured by the Federal funds rate. Figure 5 shows how FFSPR has contracted during periods of restrictive monetary policy and risen to a higher point during periods of expansive monetary policy. The low points of FFSPR would surround periods of higher contemporary inflation leading to hikes in the Federal funds rate, but without a concomitant increase in the ten-year Treasury-bond yield. The high points would be times of higher expected inflation. This connection to inflation cannot be bypassed in the context of commodity futures in this study, and hence FFSPR is included in this study.

The FFPREM acts as an intermediate of these two variables as was also suggested by Bernanke and Blinder (1992), although it has a tendency to follow the FFRATE more closely than the FFSPR. Bernanke and Blinder (1992) argue that the FFPREM provides information about future movements in real variables and Jensen, et al. (1996) argue that it can capture some of the variation in expected returns of stocks and bonds. Hence, its inclusion to this analysis is well founded.

5.1.3 Detecting Nonstationarity and Differencing the Variables

Before performing the regressions, the economic variables are examined to discover possible nonstationarity that might otherwise lead to incorrect inferences.[37] The three tests described in the methodology chapter are now used as part of the analysis. Table 3 reports the augmented Dickey-Fuller, Phillips-Perron Unit Root, and KPSS for stationarity test statistics and the corresponding p-values of the test statistics. As can be seen from the results, the augmented Dickey-Fuller tests imply that apart from the D/P and FFPREM variables the variables do contain a unit root. However, the results from the Phillips-Perron tests give a bit contradictory results, implying that FFPREM may in fact be characterised by the presence of a unit root, whereas the default spread would not have a unit root. Last, the results of the KPSS tests

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yield as a test of model misspecification, as it should not be significant if all sources of stock return predictability are included (Patelis, 1997).

[37] I want to express my gratitude to my fellow student Lauri Pietarinen for raising the issue of practical limitations in detecting nonstationarity in explanatory variables with the help of normal spreadsheet packages.

suggest that the null hypothesis of stationarity can be rejected for all of the six variables. Based on these observations, it seems reasonable to difference all the variables, although it could be argued that in the case of D/P and FFPREM it may not be necessary.

Table 3 displays the results of the same tests for the differenced variables. As table 3 shows, the null hypothesis of stationarity cannot be rejected by the KPSS test for any of the variables at traditional confidence levels. Furthermore, the hypothesis of unit root is rejected for all variables at the 1% level by the Phillips-Perron tests. Last, equivalent inferences can be made regarding the results of the augmented Dickey-Fuller tests at traditional confidence levels. As a conclusion, the ensuing section will regress the logarithmic returns against the differenced economic variables based on the observations and analysis of this section. Moreover, the variables utilized in the analysis will henceforth be differenced if not especially otherwise mentioned.

Furthermore, discussions concerning the problems and strictures of different statistical tests were extremely helpful and ideas for carrying out the computations were very useful. All errors are of course mine.

TABLE 3
Detecting Nonstationarity in Explanatory Variables

Table 3 reports the results of the augmented Dickey-Fuller tests, Phillips-Perron tests and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests for six economic variables and their first differences. The period examined is from February 1987 to February.2002 and monthly values for the variables were used. The economic variables examined were D/P, Term, Default, FFRATE, FFSPR, and FFPREM. Panel A reports the results for the variables without differencing and panel B reports the test results for the differenced variables. Augmented Dickey-Fuller tests test the null hypothesis of a unit root in the time series and the table reports the augmented Dickey-Fuller test statistic and the associated p-value. Phillips-Perron unit root tests test the null hypothesis that a unit root is present and the table reports the Dickey-Fuller Z-value and the associated p-value. KPSS tests test the null hypothesis that the time series is integrated of order zero, I(0), and the table reports the KPSS-level statistic and the associated p-value.

	Augmented Dickey-Fuller		Phillips-Perron Unit Root		KPSS for Stationarity	
Economic Variable[a]	ADF	p-value	Dickey-Fuller Z	p-value	KPSS-level	p-value
Panel A:						
D/P	-4,18	<0,01	-20,96	0,051	4,179	<0,01
Term	-1,997	0,5775	-6,510	0,742	1,010	<0,01
Default	-1,825	0,6492	-23,13	0,032	1,066	<0,01
FFRATE	-2,267	0,465	-5,017	0,827	1,402	<0,01
FFSPR	-1,571	0,756	-8,182	0,647	0,868	<0,01
FFPREM	-4,127	<0,01	-122,0	0,010	1,277	<0,01

	Augmented Dickey-Fuller		Phillips-Perron Unit Root		KPSS for Stationarity	
Differenced Economic Variable	ADF	p-value	Dickey-Fuller Z	p-value	KPSS-level	p-value
Panel B:						
diff (D/P)	-6,636	<0,01	-196,6	<0,01	0,122	>0,1
diff (Term)	-3,724	0,024	-213,7	<0,01	0,112	>0,1
diff (Default)	-6,939	<0,01	-194,6	<0,01	0,169	>0,1
diff (FFRATE)	-3,661	0,026	-219,0	<0,01	0,186	>0,1
diff (FFSPR)	-5,181	<0,01	-201,2	<0,01	0,093	>0,1
diff (FFPREM)	-7,38	<0,01	-197,3	<0,01	0,018	>0,1

[a]The economic variables examined are the dividend yield on the value-weighted S&P500 composite index [D/P], the term spread which is the difference between the yield on a ten-year Treasury bond and a three-month T-bill [Term], the default spread which is the difference between a ten-year Baa-rated corporate bond and a ten-year Treasury bond [Default], the federal funds rate [FFRATE], the federal funds spread which is the spread between the yield on a ten-year Treasury bond and the federal funds rate [FFSPR], and the federal funds premium which is the difference between the federal funds rate and the three-month T-bill rate [FFPREM]. Panel B displays the tests on the first differences of the economic variables.

5.1.4 Empirical Findings from Past Research

The aim of this section is to briefly illustrate the tangible results from past research that has employed the variables that are used in the regressions of next section. By knowing what kind of forecast power the economic variables used in this study have had in the past research in other asset classes will enable us to infer whether the forecast power obtained in the regressions of the next section for commodity futures is similar to other asset classes. Alternatively, if the signs of the slope coefficients obtained in the regressions of the next section are different, we can infer that the forecast power moves in a dissimilar cycle in commodity futures when compared with stocks and bonds.

Table 4 condenses the most relevant information from the past academic research discussed in chapter 3. It shows the signs of the coefficients for different economic variables[38] obtained in past studies in which the variables have been used to capture variation in expected returns on stocks and/or bonds. The table is by no means exhaustive but contains at least the studies that utilize methodologies that are the closest to the methodology of this thesis.

Obviously, the contents of table 4 are a simplification of the results of past studies and information regarding the significance of the results is unfortunately lost when only the sign of the coefficient of the economic variable is reported. However, the cumulative evidence from all studies reported in table 4 should give the reader a clear indication of the nature and robustness of the results concerning the forecast power of different variables. Last, the information reported in table 4 will be used in comparing the results of next section's regressions that examine the forecast power of economic variables on commodity futures, with the forecast power of the economic variables on other asset classes. This enables us to observe whether the variation in expected returns moves in a similar cycle across asset classes.

TABLE 4
Previous Findings on the Forecast Power of Economic Variables

This table reports the results from previous research that has evidenced predictable variation in returns on stocks and/or bonds captured by the economic variables used in this study. The table reports whether the sign of the slope coefficient obtained in the examination of forecast power was positive (negative) corresponding to an increase (decrease) in expected returns associated with an increase in the economic variable.

Economic Variable[a]	Sign of the coefficient for stocks	Sign of the coefficient for bonds	Previous study
Business conditions proxy:			
D/P	Positive	Positive	Fama and French (1989)
	Positive	-	Fama (1990)
	Positive	Positive	Jensen, Johnson and Mercer (1996)
	Positive	Positive	Booth and Booth (1997)
	Positive	-	Patelis (1997)
TERM	Positive	Positive	Keim and Stambaugh (1986)
	Positive	Positive	Fama and French (1989)
	Positive	Positive	Jensen, Johnson and Mercer (1996)
	Positive	Positive	Booth and Booth (1997)
	Positive	-	Patelis (1997)
DEFAULT	Positive	Positive	Keim and Stambaugh (1986)
	Positive	Positive	Fama and French (1989)
	Positive	-	Fama (1990)
	Positive	Positive	Jensen, Johnson and Mercer (1996)
	Positive	Positive	Booth and Booth (1997)
Monetary policy indicator:			
FFRATE	Negative	Negative	Booth and Booth (1997)
	Negative	-	Patelis (1997)
FFPREM	Identified as a macroeconomic variable		Jensen, Johnson and Mercer (1996)
	(Negative)	(Negative)	No previous empirical findings to report. (probable sign)
FFSPR	Positive	-	Patelis (1997)
DIR	Negative	Negative	Jensen, Johnson and Mercer (1996)
	Negative	Negative	Booth and Booth (1997)
	Negative	-	Patelis (1997)
	Negative	-	Conover, Jensen and Johnson (1999a)
	Negative	-	Conover, Jensen and Johnson (1999b)

[a]See the section 4.1 (Description of the Data) for definitions of the economic variables and comparison with definitions used for the variables in other studies.

[38] Obviously, some of the studies use somewhat different definitions for the economic variables compared to this study, but these differences are largely insignificant and the basic idea behind the rationale of each economic variable is the same in all studies.

5.1.5 The Regressions

Table 5 reports summary statistics on returns in five commodity futures classes and the GSCI. In the absence of sensitivity to economic state variables, the returns on commodity futures should be zero and the changes in futures prices entirely random. Table 5 reports the summary statistics of the returns, volatilities and correlations between the different futures classes and other assets. The examination of summary statistics before performing the regressions is done in the spirit of Bessembinder and Chan (1992), who performed a similar examination prior to searching for forecast power.

Bessembinder and Chan (1992) study commodity futures and note that their findings of zero-mean returns in futures markets are consistent with the absence of risk premia or the existence of time-varying risk premia that alternate in sign depending on the state that the economy is in. In this study, the precious metals and agricultural futures markets exhibited a substantially negative mean return. Hence, the precious metal and agricultural futures markets have on average been in contango during the period of study. To verify that the returns really deviate statistically significantly from zero, I performed t-test for the sample averages of the precious metal and agricultural futures under the null hypothesis of zero sample average, which yielded p-values of 0,02 and 0,08, respectively.[39] The conclusion could be made that these two markets may contain negative systematic risk to the state variables as they have yielded statistically significant negative returns during the period of the study.

Industrial metals, energy and livestock futures had positive excess returns during the study period, implying that they may expose the long investor to positive systematic risk (Performing a standard t-test under the null hypothesis of zero-mean returns yields a p-value of 0,42 for the livestock futures. The industrial metal and energy futures and stock excess returns did not deviate statistically significantly from zero under conventional confidence levels.) Furthermore, the returns on industrial metal and energy futures outperformed also Treasury bond holdings during the period of the study and returns on the industrial metal futures investment were also higher than an investment in the S&P500. The volatility was on average higher in the commodity futures market than in the other markets.

[39] The results of the t-tests are not reported in table 5.

Precious metal and energy futures investments were negatively correlated with equities and all commodity futures classes except livestock futures had a negative correlation with Treasury bonds during the period of study. The negative correlations were statistically significant between precious metal futures and stocks and between energy futures and Treasury bonds. This negative correlation might have been helpful for investors in achieving diversification by adding commodities in their portfolios. On the other hand, there were statistically significant positive correlations between stocks and both industrial metal futures and Treasury bonds. The only statistically significant positive correlation was between precious metal and energy futures.

The reason for examining the excess returns deviation from zero is that one of the explanation for return predictability given in the finance literature has been different asset classes' possible sensitivity to common economic state variables and the predictive power of the economic variables on these state variables. For example, Chen (1991) showed that two of the business condition proxies were related to and forecasted future and past output growth, hence implying that their forecast power may be linked to some underlying economic state variables. Hence, zero-mean returns would imply no forecast power by the economic variables if the situation were interpreted strictly. A definite criticism against this type of examination is obviously the fact that there may be many other state variables that an asset is exposed to that would impact the risk-return profile of that asset. However, there is no denying of the fact that since we do not know the economic state variables, even this kind of simple observation can tell some things about the nature of the asset and be helpful in interpreting the results. Last, similar examination was done by Bessembinder and Chan (1992) in their early study on a similar topic.

TABLE 5

Summary Statistics of Excess Returns on Stocks, Bonds and Commodity Futures

This table reports the mean monthly returns, mean monthly excess returns, standard deviations of the monthly excess returns and the correlations of the excess returns between stocks, Treasury bonds, five commodity futures classes and the GSCI [See the section Description of the Data for closer details of the return indexes]. The period of the study was February 1987 to February 2002. The significance of the correlations' deviations from zero were tested and the significance levels are indicated by asterisks as defined below the table.

Returns, Standard Deviations and Correlations for Alternative Investments

				Excess Return Correlations						
Index	Mean Monthly Return (%)	Mean Monthly Excess Return (%)	Excess Return Standard Deviation	Stocks	Treasury Bonds	Precious Metals	Industrial Metals	Livestock	Energy	Agricultural
Stocks	0,957	0,461	4,689	1						
Treasury Bonds	0,697	0,261	2,441	0,147*	1					
Precious Metals	-0,077	-0,522	3,368	-0,179*	-0,043	1				
Industrial Metals	0,977	0,506	6,815	0,153*	-0,016	0,089	1			
Livestock	0,584	0,117	3,782	0,095	0,080	0,023	-0,011	1		
Energy	0,816	0,464	8,686	-0,117	-0,225**	0,150*	0,070	0,084	1	
Agricultural	0,004	-0,456	4,382	0,062	-0,088	-0,013	0,142	0,028	-0,002	1
GSCI	0,000	0,217	4,996	-0,0764**	-0,228**	0,175*	0,145	0,195**	0,960**	0,219**

n = 180 months.
* significant at the 5% level
** significant at the 1% level

Table 6 shows how the business condition proxies have information about the expected returns on some of the commodity futures markets. The R^2 is relatively high for industrial metal and also energy futures, which suggests that the variables that have been identified to possess forecast power in stocks and bonds, also forecast the returns on selected commodity futures classes, namely the industrial metal and energy futures. In fact, the coefficient of determination on the industrial metals market is at the higher end compared to the studies that use the same variables in detecting predictability in stock and bond markets, as the R^2 in earlier studies have been approximately around 0,02 and 0,08 when predicting monthly returns.

The analysis yields coefficients for excess returns on industrial metal futures that have signs consistent with those of stocks and corporate bonds with respect to the D/P and Default variables. Furthermore, all three coefficients of the variables are significant at the 10% level. What is interesting is the negative sign of the Term variable produced by the regressions. This would be consistent with the earlier discussed idea that excess returns on some commodity futures may be positively related to the contemporary business conditions, which have been argued to be followed most closely by the term spread. This view would state that as the business conditions are peaking and the term spread is contracting, the expected returns on investing in metal futures should rise. What makes this interesting is the fact that both stocks and bonds have positive signs for the term variable and hence the expected returns on stocks and bonds are lower when business is peaking whereas metal futures would be expected to produce higher returns when the term spread is smaller. Therefore, even though the three variables possess forecast power for stocks, bonds, and industrial metal futures, they track the expected returns in these markets differently with respect to the contemporary business variable, i.e. the term spread.

Another class of commodity futures where the variables predicted the returns significantly was energy. For energy futures the coefficient of determination was decidedly lower than for industrial metal futures. However, the R^2 was at a level that has been interpreted to advocate the proposition of significant predictability on variation in expected returns in the stock and bond markets in past academic research and the p-value of the regression is 0,068. Energy futures have similar sign coefficients to those found for stocks and bonds except with respect to default spread. The sign of the default spread coefficient was negative and significant at the 5% level. The default spread and the term spread deviated significantly from zero at the 10%

level, whereas the dividend yield was not significant. Chen (1991) argued that the default spread is negatively correlated with past output growth. Hence, a large default spread would correspond to no growth in output and the negative sign in the energy regression implies that this would predict smaller excess returns in the energy futures market whereas in the equity and bond markets the reversal finding has been made in various studies mentioned in the section covering the past literature on the issue.

For the three other commodity futures markets, there did not exist any significant forecast power in the three variables employed as becomes apparent from table 6.[40] The observation that similar variables do forecast returns in some of the commodity futures markets may imply that they are exposed to similar state variables. On the other hand, for the three other futures classes the close to zero or negative returns observed earlier suggest that they should not possess systematic risk similar to stocks and bonds.

[40] The Durbin-Watson tests did not imply significant autocorrelation in the residuals for any of the regressions in tables 6,7, or 8.

TABLE 6
Regressions on Business Condition Variables

This table contains the results from a set of multivariate regressions. The excess returns on five commodity futures classes and the GSCI at monthly horizons were regressed on one lag of all three column variables [D/P, TERM, DEFAULT]. The table reports the estimated monthly regression coefficients and the associated p-values of the regression coefficients' t-tests. The model specification was tested and the table reports the F-statistics and the associated p-values for all regressions. Autocorrelation in the residuals was tested with the Durbin-Watson test and the critical values for D_L and D_U with 3 explanatory variables, a sample size of 100 (the exact sample size used was 178) and critical probability of 0,05 are 1.61 and 1.74, respectively. The study period was from the period between February 1987 and February 2002.

Market	Instrumental Variable[a]					Test for Model Spedification		Residuals
	Intercept	D/P	TERM	DEFAULT	Regression R^2	F-value	(p-value)	Durbin-Watson
	$r(t,t+T) = a + bD/P + cTERM + dDEFAULT + e(t,t+T)$							
(1) Precious Metals	-0,536	-0,115	1,385	1,345	0,022	1,303	(0,275)	2,147
	(0,034)	(0,958)	(0,113)	(0,336)				
(2) Industrial Metals	0,643	15,128	-2,912	4,627	0,086	5,495	(0,000)	1,852
	(0,192)	(0,000)	(0,089)	(0,091)				
(3) Livestock	0,116	-0,232	-0,323	0,799	0,002	0,117	(0,950)	2,063
	(0,685)	(0,925)	(0,744)	(0,614)				
(4) Energy	0,458	0,846	4,175	-7,397	0,040	2,420	(0,068)	1,656
	(0,477)	(0,878)	(0,062)	(0,039)				
(5) Agricultural	-0,438	1,516	-0,532	-1,080	0,005	0,286	(0,835)	2,137
	(0,186)	(0,592)	(0,642)	(0,556)				
(6) GSCI	0,223	1,315	1,890	-3,735	0,029	1,781	(0,152)	1,762
	(0,549)	(0,680)	(0,143)	(0,071)				

[a]The excess returns are regressed on (the first differences of) three economic variables, namely the dividend yield on the value-weighted S&P500 composite index [D/P], the term spread which is the difference between the yield on a ten-year Treasury bond and a three-month T-bill [TERM] and the default spread which is the difference between a ten-year Baa-rated corporate bond and a ten-year Treasury bond [DEFAULT].

In table 7 the directional rate-change dummy DIR is added to the regressions that were presented above to see whether the reported augmentation in the forecast power on stocks and bonds by Jensen et al. (1996) and Booth and Booth (1997) will be observed in the context of commodity futures. Earlier studies report a negative coefficient on the DIR variable when regressed with stocks and bonds implying that tightening monetary policy (increasing rates and a DIR value of 1) will reduce the expected returns on stocks and bonds.

The addition of the DIR variable enhances the forecast power but does not change the nature of the results with respect to the forecast ability of common variables in stocks, bonds and different commodity futures classes.[41] The first observation that is to be made regards the coefficient of the DIR variable across the commodity futures classes. The coefficient of the DIR variable is positive for all commodity futures, although it is significant at traditional levels only in the case of energy and industrial metals. Furthermore, the forecast ability of the model is again significant only in the case of industrial metals and energy futures.

In the case of industrial metals, the R^2 is 0,106 and it can again be observed that the coefficient of the term variable remains negative in contrast to stocks and bonds as reported by Jensen et al. (1996) and Booth and Booth (1997). The DIR variable and the dividend yield are both significant in the model, whereas Term is not significantly different from zero.

The term spread, default spread and DIR are all significant at the 5 % level in predicting returns on energy futures. Moreover, the dividend yield does not have any explanatory power even after the addition of the DIR variable. The coefficient of determination is high for both energy and industrial metal futures and the adjusted R^2's are higher than those reported by for instance Booth and Booth (1997).[42] This implies that monetary policy is an important variable in capturing variation in expected returns in energy and industrial metals markets. Last, an interesting result is the finding of significantly higher forecast power on the aggregate GSCI when the DIR variable is added to the regressions and all the slope coefficients except the dividend yield are significant at the 5% level.

[41]The adjusted R^2 for industrial metal and energy futures is higher when the DIR variable is included in the study.

[42]Adjusted R^2's were in the range of 0,01-0,05 in the study of Booth and Booth (1997) whereas here they are above 0,08 for both energy and industrial metal futures.

TABLE 7

Regressions on Business Condition Proxies and the Directional Rate-Change Dummy Variable

This table contains the results from a set of multivariate regressions. The excess returns on five commodity futures classes and the GSCI at monthly horizons were regressed on one lag of all four column variables [D/P, TERM, DEFAULT, DIR]. The table reports the estimated monthly regression coefficients and the associated p-values of the regression coefficients' t-tests. The model specification was tested and the table reports the F-statistic and the associated p-values for all regressions. Autocorrelation in the residuals was tested with the Durbin-Watson test and the critical values for D_L and D_U with 4 explanatory variables, a sample size of 100 (the exact sample size used was 178) and critical probability of 0,05 are 1.59 and 1.76, respectively. The study period was from the period between February 1987 and February 2002.

	Instrumental Variable[a]					Regression	Test for Model Specification		Residuals
Market	Intercept	D/P	TERM	DEFAULT	DIR	R^2	F-value	(p-value)	Durbin-Watson
	$r(t,t+T) = a + bD/P + cTERM + dDEFAULT + eDIR + e(t,t+T)$								
(1) Precious Metals	-0,571	-0,171	1,423	1,338	0,083	0,022	0,978	(0,421)	2,145
	(0,095)	(0,938)	(0,118)	(0,340)	(0,876)				
(2) Industrial Metals	-0,232	13,742	-1,987	4,463	2,031	0,106	5,164	(0,001)	1,895
	(0,725)	(0,001)	(0,258)	(0,101)	(0,050)				
(3) Livestock	-0,060	-0,510	-0,137	0,766	0,408	0,005	0,203	(0,937)	2,072
	(0,876)	(0,837)	(0,894)	(0,629)	(0,499)				
(4) Energy	-1,486	-2,232	6,230	-7,763	4,510	0,100	4,869	(0,001)	1,729
	(0,079)	(0,681)	(0,006)	(0,026)	(0,001)				
(5) Agricultural	-0,829	0,896	-0,118	-1,153	0,909	0,015	0,644	(0,632)	2,153
	(0,064)	(0,754)	(0,921)	(0,528)	(0,192)				
(6) GSCI	-0,997	-0,617	3,180	-3,965	2,831	0,102	4,946	(0,001)	1,866
	(0,040)	(0,843)	(0,014)	(0,048)	(0,000)				

[a]The excess returns are regressed on four economic variables, namely the dividend yield on the value-weighted S&P500 composite index [D/P], the term spread which is the difference between the yield on a ten-year Treasury bond and a three-month T-bill [TERM], the default spread which is the difference between a ten-year Baa-rated corporate bond and a ten-year Treasury bond [DEFAULT] and the directional rate-change dummy which gets a value of one (zero) if the latest change in the Federal Reserve discount rate was an increase (decrease) implying that the monetary policy is restrictive (expansive) [DIR].

The addition of the DIR variable in the regressions and the subsequent increase in the forecast power of the variables implies that monetary variables might in fact be the most suitable ones for capturing predictable variation in expected returns on commodity futures. This would also be intuitively compelling since increases in unexpected inflation might very well be closely linked to the monetary sector. Moreover, if unexpected inflation is related to the monetary sector, then monetary variables should explain variation in commodity futures returns. This further motivates the use of a third set of regressions where excess returns on commodity futures are regressed on a set of monetary variables.

An interpretation regarding the first and second hypothesis is presented at this point. First, after the first two sets of regression it seems that some, not all, previously identified economic variables have forecast power on the returns on energy and industrial metal futures. Hence, the results so far support the rejection of the null on hypothesis 1. Second, the signs of significant slope coefficients have alternated in sign from that forecasted for stocks and bonds, and there were also differences among energy and industrial metal futures. An important finding in answering the derived research question was that the sign on the DIR variable was positive for all commodity futures classes, in contrast to the negative slope reported for both stocks and bonds, and it was statistically significant for energy and industrial metal futures.[43] Next, the last set of regressions on monetary variables is presented.

Table 8 shows how monetary policy proxies have information about the expected returns on commodity futures markets.[44] Panel A of table 8 regresses the excess returns against the federal funds rate, federal funds spread and the DIR indicator and panel B replaces the federal funds spread with the federal funds premium. I also report the regressions of the excess returns of S&P500 on the new variables since earlier empirical research has not used extensively this set of variables in capturing predictable variation in expected returns on stocks.

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[43] The DIR was also statistically significantly positive for precious metal futures at the 10% significance level.

[44] The reason for not including business condition proxies in the regressions with monetary variables is the high correlation with the spread variables used as business condition and monetary policy proxies.

TABLE 8
Regressions on Monetary Variables

This table contains the results from multivariate regressions. The excess returns on five commodity futures classes, the GSCI and the S&P500 at monthly horizons were regressed on one lag of three of the four column variables [FFRATE, FFSPR, FFPREM, DIR] in panels A and B. The table reports the estimated monthly regression coefficients and the associated p-values of the regression coefficients' t-tests. The model specification was tested and the table reports the F-statistics and the associated p-values for all regressions. Autocorrelation in the residuals was tested with the Durbin-Watson test and the critical values for D_L and D_U with 3 explanatory variables, a sample size of 100 (the exact sample size used was 178) and critical probability of 0,05 are 1.61 and 1.74, respectively. The study period was from the period between February 1987 and February 2002. (The table continues on the next page).

	Instrumental Variable[a]					Regression	Test for Model Specification		Residuals
Market	Intercept	FFRATE	FFSPR	FFPREM	DIR	R^2	F-value	(p-value)	Durbin-Watson
	$r(t,t+T) = a + bFFRATE + cFFSPR + dDIR + e(t,t+T)$								
Panel A:									
(1) S&P500	1,736	-2,607	0,296		-2,354	0,042	2,601	0,054	1,932
	(0,007)	(0,050)	(0,853)		(0,018)				
(2) Precious Metals	-0,517	0,478	1,187		-0,007	0,011	0,650	0,584	2,166
	(0,138)	(0,710)	(0,176)		(0,989)				
(3) Industrial Metals	-0,717	-0,052	0,999		2,875	0,041	2,505	0,061	1,903
	(0,301)	(0,984)	(0,566)		(0,008)				
(4) Livestock	-0,159	-1,513	-0,382		0,573	0,009	0,540	0,655	2,070
	(0,684)	(0,300)	(0,698)		(0,348)				
(5) Energy	-0,530	10,008	4,738		2,851	0,098	6,349	0,000	1,802
	(0,536)	(0,002)	(0,029)		(0,034)				
(6) Agricultural	-0,747	2,007	0,820		0,790	0,020	1,201	0,311	2,172
	(0,098)	(0,229)	(0,469)		(0,262)				
(7) GSCI	-0,500	5,672	2,794		1,977	0,111	7,297	0,000	1,939
	(0,307)	(0,002)	(0,024)		(0,010)				

Market	Intercept	FFRATE	FFSPR	FFPREM	DIR	Regression R^2	F-value	(p-value)	Durbin-Watson
		r(t,t + T) = a + bFFRATE + cFFPRM + dDIR + e(t,t + T)							
Panel B:									
(1) S&P500	0,825	-0,071		-5,718	-0,886	0,051	3,172	0,026	2,064
	(0,083)	(0,967)		(0,012)	(0,230)				
(2) Precious Metals	-0,501	-0,452		0,793	-0,074	0,002	0,109	0,955	2,169
	(0,153)	(0,722)		(0,635)	(0,891)				
(3) Industrial Metals	-0,597	1,071		-6,128	2,654	0,058	3,603	0,015	1,892
	(0,385)	(0,668)		(0,063)	(0,014)				
(4) Livestock	-0,171	-1,342		0,200	0,605	0,008	0,493	0,688	2,075
	(0,662)	(0,346)		(0,915)	(0,320)				
(5) Energy	-0,524	5,277		6,802	2,672	0,087	5,585	0,001	1,873
	(0,544)	(0,094)		(0,010)	(0,047)				
(6) Agricultural	-0,689	2,198		-2,426	0,672	0,024	1,456	0,228	2,160
	(0,126)	(0,180)		(0,260)	(0,336)				
(7) GSCI	-0,472	3,310		2,485	1,835	0,090	5,813	0,001	1,950
	(0,341)	(0,067)		(0,294)	(0,018)				

[a]The excess returns are regressed on four monetary policy variables, namely the federal funds rate [FFRATE], the federal funds spread which is the spread between the federal funds rate and ten-year Treasury bond yield [FFSPR], the federal funds premium which is the spread between the federal funds rate and three-moth T-bill yield [FFPREM], and the directional rate-change dummy which gets a value of one (zero) if the latest change in the Federal Reserve discount rate was an increase (decrease) implying that the monetary policy is restrictive (expansive) [DIR].

As a general note, it is again the case that the only commodity futures which have expected returns that are predicted by the economic variables are energy and industrial metals, and the variables also forecast returns on the S&P500.[45]

The results of the regressions show that the returns on energy futures are relatively strongly influenced by the monetary sector and the resulting R^2 of 0,098 is high compared to the previous stock return predictability research or the results of Bessembinder and Chan (1992).[46] The resulting regression coefficients are all positive for energy futures and significant at traditional levels, and the three variables seem to capture predictable variation in expected returns on energy futures well. In the case of industrial metal futures the only significant coefficient is the DIR variable. With the S&P500 the coefficients of FFRATE and DIR are negative and significant at traditional levels. The opposite-sign coefficients estimated to stocks imply that when the FFRATE is influenced by an innovation causing an increase or the DIR variable has a value of one, the expected returns on stocks are negatively affected whereas the expected returns on energy and industrial metal futures are increased.

The results of the regressions presented in panel B of table 8 in which the federal funds spread is replaced with the funds premium are similar in character to the results of panel A. The regression R^2's are increased somewhat for industrial metal futures and for the S&P500, but the R^2 for energy futures declines. The signs of the coefficients are similar to those of the previous set of regressions. The model is again not significant for the other three commodity futures classes.

Next section compares the cycle of predictable variation found in the regressions of this section with the findings presented in section 5.1.4. for predictable variation in expected returns of stocks and bonds.

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[45] The models have also significant forecast power on the excess returns of the GSCI, which is not surprising as the GSCI incorporates energy as the highest weighted commodity class.

[46] Bessembinder and Chan used two yield curve variables relatively similar to the business condition variables used earlier and obtained regression R^2's that were in the range of 0,028-0,070. Patelis (1997) reports predictability in stock returns using both monetary and financial variables with a relatively high adjusted R^2 of 0,084. This is in comparison to the adjusted R^2 's of 0,082 on energy futures and 0,095 on the GSCI, respectively (Adjusted R^2's not reported).

5.1.6 Examination of the Cycle of Variation

After the four sets of regressions presented in the previous section it seems that some, not all, previously identified economic variables have forecast power on returns in energy and industrial metal futures. Hence, the cumulated results support the rejection of the null on hypothesis 1. In other words, the results of this study suggest that economic variables do in fact capture variation in expected returns in commodity futures, and most notably in energy and industrial metal futures markets.

Hypothesis 2 states that the forecast variables' slope coefficients should have common signs across markets. This would be in accordance with the predictions of Fama (1991). To be able to address hypothesis 2, I have gathered the results of the previous section in table 9 with the results from other studies conducted with the stock and bond markets presented in section 5.1.4.[47]

The results presented in table 9 are engrossing. The slope coefficients of various economic variables for energy, industrial metal, and the GSCI futures alternate in sign from the slopes of the variables for stock and bond returns.[48] Furthermore, the differences in the signs of the slopes seem to be most distinctive with monetary variables. This evidence suggests rejection of the null on hypothesis 2.

Interestingly enough, the difference between the forecast variables is the strongest with respect to the discount-rate-change dummy DIR. This suggests that during times of stringent Federal Reserve monetary policy associated with increasing discount rates, expected returns on energy and industrial metal futures are higher than normally whereas the returns on stocks

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[47] Since the results from previous studies suggest that the signs of the slope coefficients are the same across both stock and bond markets, I have only included a column that reports the signs of the slopes for stocks.

[48] In table 8 there are a total of nine out of 21 economic variables for which the sign of the slope coefficient is different from the sign of the slope coefficient for traditional assets, and for which the slope was significant at least at the ten per cent confidence level. In contrast, there were only six significant slope coefficients that were similar in sign to traditional assets. This leaves six slopes of economic variables that were not significant at the traditional confidence intervals.

The slopes that were significant and produced a similar sign to stocks and bonds were the FFPREM and the dividend yield for industrial metal futures, the Term spread and the FFSPR for energy futures [the Term spread and the FFSPR are relatively similar variables both containing information on the term structure of interest rates], and the Term spread and the FFSPR for the GSCI.

TABLE 9
Comparison of Previous and Current Findings to Determine Differences in the Cycle of Variation

This table compares previous findings on the predictive power of economic variables on expected returns in stock markets with the findings reported in the previous section on the predictive power of economic variables on energy, industrial metal, and the GSCI futures. The table reports whether the sign of the coefficient obtained in the examination of the forecast power was positive (negative) corresponding to an increase (decrease) in expected returns associated with an increase in value of the economic variable. The reported signs in the column Predicted sign for stocks are extracted from table 4. The results that are bolded are different in sign from the results reported in the column Predicted sign for stocks, and they were also significant in the regressions of the previous section at the ten per cent confidence level. The bolded results essentially imply difference in the cycle of predictable variation with respect to the particular economic variable.

Economic Variable[a]	Predicted sign for stocks	Energy futures	Industrial metal futures	GSCI
Business conditions proxy:				
D/P	Positive	Positive/not significant	Positive	Positive/not significant
TERM	Positive	Positive	**Negative**	Positive
DEFAULT	Positive	**Negative**	Positive	**Negative**
Monetary policy indicator:				
FFRATE	Negative	**Positive**	Positive/not significant	**Positive**
FFPREM	Negative	**Positive**	Negative	Positive
FFSPR	Positive	Positive	Positive/Not significant	Positive
DIR	Negative	**Positive**	**Positive**	**Positive**

[a]See the section 4.1 (Description of the Data) for definitions of the economic variables and comparison with definitions used for the variables in other studies, and table 4 for previous findings on the forecast power of economic variables on stocks and bonds.

are lower. This formally motivates the use of the DIR variable in guiding asset allocation between traditional assets and commodity futures, and the issue is tackled in section 5.2.2.

5.2 Empirical Results on the Risk-Return Tradeoff

This section of the study will research the returns on commodity futures compared with returns on common stocks and bonds much like in the spirit of the early findings of Bodie and Rosansky (1980) who reported evidence in favour of adding commodity futures to the standard portfolio. I will first look at commodity futures' performance in general in section 5.2.1 and then illustrate how the finding of predictable variation in expected returns could be taken advantage of in an enhanced portfolio allocation between the different asset classes in section 5.2.2.

5.2.1 Risk and Return in Different Commodity Futures Classes

Table 10 reports the returns, standard deviations and correlations during the period of study. Energy, industrial metals and livestock outperformed the returns on T-bills during the study period. The return on industrial metals was even higher than the return on equities, although also the standard deviation of the return was considerable higher. Furthermore, returns on energy and industrial metals are also characterized by a relatively high negative correlation with stocks and bonds. In addition, all the commodity futures classes had a negative correlation with bonds.

The first observation that can be made is that especially industrial metals and energy would have been attractive vehicles of portfolio diversification due to their high returns and negative correlation with traditional assets. However, their high standard deviations would probably have reduced their attractiveness as stand-alone investments, and hence it seems that commodity futures are more attractive as portfolio components.

Table 11 provides a more formal examination of the diversification benefits of commodity futures by showing the optimal weights allocated to different asset classes calculated by Markowitz portfolio optimisation over a range of risk levels. The table shows how commodity futures are included in the efficient portfolio during the study period, and especially how the weight allocated to industrial metal futures substantially rises as the risk level is increased. Furthermore, the table reports the increase in the portfolio return when commodity futures are added to the investors' optimisation problem. As is clearly seen, the portfolio returns are enhanced with the addition of commodity futures.

The examination of the diversification potential of commodity futures and their improvement in the efficient set is illustrated in figure 6 by showing two alternative efficient frontiers: the first includes stocks, bonds, and T-bills; the second set incorporates the five different futures classes as a fourth component in the portfolio. The efficient frontiers are constructed the same way as the weights in table 11, i.e. assuming no short-selling of assets. Figure 6 demonstrates how commodity futures allow an investor to achieve a more favorable portfolio during the period of study and shows the improvement in the risk-return tradeoff associated with the introduction of commodity futures to the investment mix. This is notable especially at intermediate levels of portfolio risk.

Overall the results of this section suggested that commodity futures would have provided an addition to the standard portfolio during the past 15 years. The low correlation between commodity futures and other asset classes coupled with substantial returns on especially industrial metal futures and energy futures would have provided an investor with diversification potential, and hence an allocation for commodity futures in efficient portfolios.

TABLE 10

Summary Statistics on Returns of Stocks, Bonds, T-bills, and Commodity Futures Classes

Table 10 reports mean monthly returns, yearly returns, standard deviations of the monthly returns and correlations of the returns between stocks, Treasury bonds, T-bills, five commodity futures classes and the GSCI [See the section Description of the Data for closer details of the return indexes]. The period of the study was February 1987 to February 2002. The significance of the correlations' deviations from zero were tested and the significance levels are indicated by asterisks as defined below the table.

Returns, Standard Deviations and Correlations for Alternative Investments

				Correlations							
	Mean Monthly Return (%)	Mean Yearly Return (%)	Standard Deviation	Stocks	Treasury Bonds	T-bills	Precious Metals	Industrial Metals	Livestock	Energy	Agricultural
Stocks	0,957	11,479	4,511	1							
Treasury Bonds	0,697	8,361	2,439	0,149*	1						
T-bills	0,462	5,549	0,142	0,057	0,115	1					
Precious Metals	-0,077	-0,930	3,692	-0,022	-0,075	-0,039	1				
Industrial Metals	0,977	11,726	6,442	-0,192*	-0,116	0,115	0,113	1			
Livestock	0,584	7,003	3,613	0,068	-0,036	0,106	0,055	-0,009	1		
Energy	0,816	9,792	8,875	-0,110	-0,063	0,180*	0,140	0,151*	0,109	1	
Agricultural	0,004	0,054	4,249	0,053	-0,061	0,001	0,067	0,138*	0,176*	0,038	1
GSCI	0,705	8,461	4,959	-0,046	-0,059	0,156*	-0,024	0,167*	-0,008	0,369**	-0,025

n = 180 months.
* significant at the 5% level
** significant at the 1% level

TABLE 11

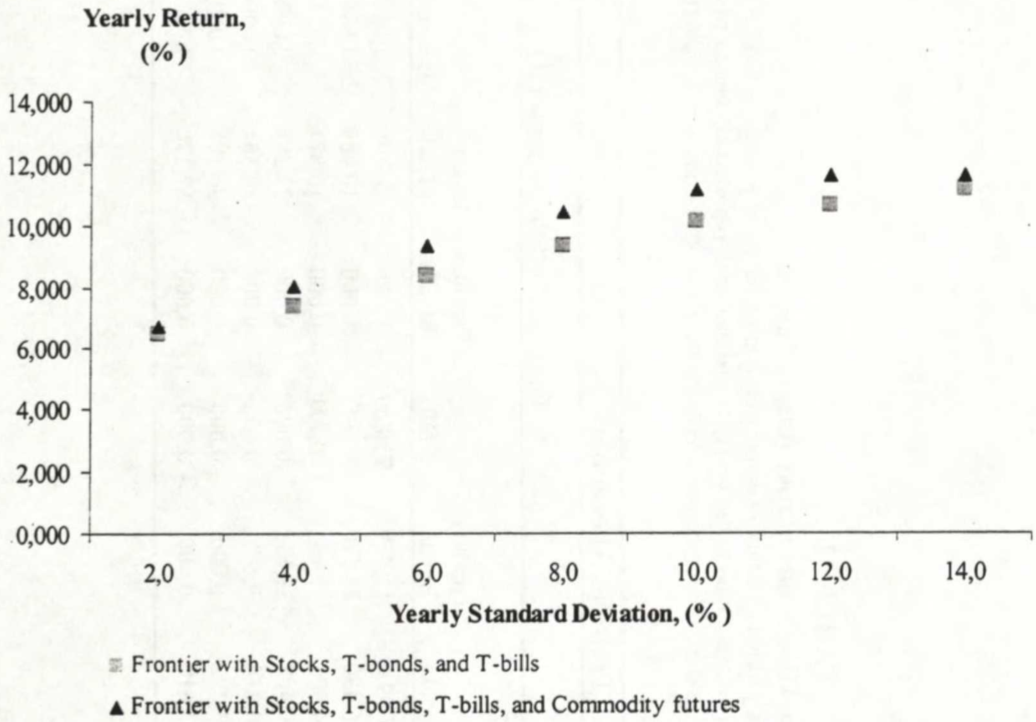
Optimal Portfolio Allocations across Asset Classes

This table reports the optimal portfolio allocations for different asset classes yielded by Markowitz portfolio optimisation at a range of risk levels (defined by the standard deviation of the portfolio) during the period from February 1987 to 2002. This table reports the yearly return that each reported allocation would have yielded during the study period and an equivalent yearly return when the optimal portfolio would have been constructed only from stocks, bonds and T-bills (the weight assigned to each class are not reported in the table in the latter case).

Optimal Portfolio Allocations										
			Optimal Portfolio weights (%)							
Yearly Standard Deviation	Yearly Return of Portfolio Excluding Commodities (%)	Yearly Return of Portfolio Including Commodities (%)	Stocks	Treasury Bonds	T-bills	Precious Metals	Industrial Metals	Livestock	Energy	Agricultural
2,0	6,457	6,746	7,991	11,769	71,869	0,000	5,019	2,145	1,207	0,000
4,0	7,421	8,047	16,480	24,570	41,147	0,000	10,469	4,604	2,730	0,000
6,0	8,375	9,334	24,921	37,162	10,771	0,000	15,871	7,035	4,241	0,000
8,0	9,327	10,455	39,408	31,635	0,000	0,000	23,288	0,000	5,669	0,000
10,0	10,114	11,157	54,234	9,577	0,000	0,000	30,361	0,000	5,829	0,000
12,0	10,655	11,595	53,292	0,000	0,000	0,000	46,708	0,000	0,000	0,000
14,0	11,128	11,633	37,610	0,000	0,000	0,000	62,390	0,000	0,000	0,000

FIGURE 6
Efficient Frontiers During the Period of Study

This figure shows the improvement in the risk-return tradeoff associated with the introduction of commodity futures to the investment mix. The frontiers were calculated by Markowitz portfolio optimization. The study period was between February 1987 to February 2002. The indexes used are described in section Description of Data. The weights assigned to each commodity futures class in the efficient portfolio are reported in table 11.



As a conclusion of this section, I will turn back to hypothesis 3 presented earlier. As has become evident, incorporating commodity futures into an investment portfolio would have been a valuable addition to a standard portfolio consisting of stocks, bonds, and T-bills during the past 15 years. Hence, the null of no improvement in the risk-return tradeoff associated with the introduction of commodity futures to the investment mix of hypothesis 3 can be rejected. On the other hand, none of the commodity futures classes appeared to be significantly better than stocks because of their high volatility during the period of the study.

5.2.2 The Impact of Monetary Policy on the Risk-Return Tradeoff

This section examines the diversification benefits of commodity futures when accounting for changes in monetary stringency and thus utilizing the findings of predictable variation in expected returns across different asset classes. The DIR variable described earlier is used in differentiating between expansive and restrictive monetary stringency periods. A month is classified as expansive (restrictive) if the most recent change in the Federal Reserve discount rate was a(n) decrease (increase). This ex ante measure requires only past information and would have allowed an investor to reallocate portfolio weights over the period in an ex ante manner.

Panels A and B in table 12 report mean monthly and yearly returns, monthly standard deviations, and correlations of the different asset classes' returns for expansive and restrictive monetary periods, respectively. The study period included 101 months in expansive periods, 73 months in restrictive periods, and 6 months that were excluded because these months included days in both monetary environments (because of a change in the discount rate that was opposite to the previous change by the Fed), as reported in table 1. The study period was accordingly dichotomised into expansive and restrictive periods to enable the examination.

The mean returns reported in table 12 show a substantial difference in the performance of many of the asset classes. Especially pronounced are the performance differences for stocks, industrial metal futures, and energy futures. Furthermore, the difference in returns is also very high for agricultural futures (a difference in mean returns of almost 15% p.a. between restrictive and expansive periods). The returns on the stock performance benchmark used in this study were over 7% p.a. smaller during restrictive monetary periods, whereas the returns on industrial metal and energy futures were over 30% on a yearly basis during restrictive monetary policy, the two futures classes yielding negative returns during periods of expansive monetary policy.

TABLE 12

Returns, Standard Deviations, and Correlations of Asset Classes During Periods of Expansive and Restrictive Monetary Policy

This table reports the monthly mean returns, yearly mean returns, monthly standard deviations and the correlations between stocks, Treasury bonds, T-bills, five commodity futures classes and the aggregate commodity futures portfolio GSCI during periods of two different monetary policies. The results are for the period starting from February 1987 to February 2002. Panel A reports the results for the 101 months when the monetary policy was expansive as indicated by the directional rate-change dummy variable DIR, meaning that the latest change in the Federal Reserve's discount rate was a decrease. Panel B reports the results for the months where the latest change in the discount rate was an increase implying that the Federal Reserve's monetary stance is considered restrictive. The months in which a change in opposite direction occurred were eliminated from the study. The significance of the correlations' deviations from zero was tested and the significance levels are reported with an asterisk.

Returns, Standard Deviations and Correlations for Alternative Investments

				Correlations							
	Mean Monthly Return (%)	Mean Yearly Return (%)	Standard Deviation	Stocks	Treasury Bonds	T-bills	Precious Metals	Industrial Metals	Livestock	Energy	Agricultural
Panel A: Expansive Monetary Policy (101 months)											
Stocks	1,214	14,573	4,171	1							
Treasury Bonds	0,448	5,379	2,380	0,136	1						
T-bills	0,400	4,794	0,115	0,219*	0,065	1					
Precious Metals	-0,062	-0,740	3,434	-0,099	-0,115	-0,046	1				
Industrial Metals	-0,251	-3,014	4,747	-0,134	-0,165	0,007	0,179	1			
Livestock	0,316	3,795	3,537	-0,007	-0,121	0,002	0,130	0,110	1		
Energy	-0,782	-9,381	8,282	-0,056	-0,126	0,070	0,063	0,196	0,230*	1	
Agricultural	-0,510	-6,121	4,229	0,038	-0,218*	-0,038	0,172	0,053	0,253**	0,126	1
GSCI	-0,273	-3,276	4,741	0,151	-0,036	0,021	-0,089	0,085	0,058	0,314**	-0,012
Panel B: Restrictive Monetary Policy (73 months)											
Stocks	0,604	7,246	4,946	1							
Treasury Bonds	1,037	12,441	2,493	0,185	1						
T-bills	0,548	6,581	0,129	-0,007	0,059	1					
Precious Metals	-0,099	-1,189	4,042	0,054	-0,032	-0,038	1				
Industrial Metals	2,658	31,897	7,947	-0,218*	-0,141	-0,008	0,076	1			
Livestock	0,949	11,393	3,707	0,164	0,045	0,151	-0,027	-0,140	1		
Energy	3,002	36,028	9,242	-0,143	-0,051	0,100	0,229*	0,050	-0,068	1	
Agricultural	0,709	8,504	4,201	0,094	0,103	-0,147	-0,053	0,163	0,052	-0,137	1
GSCI	2,043	24,522	4,968	-0,233*	-0,156	0,069	0,049	0,157	-0,138	0,364**	-0,123

Total n = (180-6) =174

* significant at the 5% level

** significant at the 1% level

TABLE 13

Tests for Differences in Returns and Risk across Monetary Environments

The differences in mean monthly returns between periods of expansive and restrictive monetary policy were calculated across the different asset classes and they are reported in this table. T-tests were used in testing whether the difference in returns deviates statistically significantly from zero and F-tests for the differences in standard deviations across asset classes. The study period was February 1987 to February 2002. The difference was calculated by subtracting the result for expansive periods from the equivalent result for the periods of restrictive monetary policy, where the monetary stringency was identified by the directional rate-change dummy DIR, implying that a month was expansive (restrictive) if the latest change in the Federal Reserve's discount rate was a(n) decrease (increase). Significance in test statistics is marked with an asterisk(s) as defined below the table.

Tests for Differences in Returns and Risk Across Monetary Environments		
Index	Difference in Mean Monthly Returns (%) (t-statistic)	Difference in Standard Deviation of Monthly Returns (F-statistic)
Stocks	-0,611	0,776
	(-0,873)	(1,407)
Treasury Bonds	0,589	0,114
	(1,594)	(1,098)
T-bills	0,149	0,014
	(7,990)**	(1,268)
Precious Metals	-0,037	0,609
	(-0,065)	(1,386)
Industrial Metals	2,909	3,200
	(2,842)**	(2,803)**
Livestock	0,633	0,171
	(1,154)	(1,098)
Energy	3,784	0,960
	(2,833)**	(1,245)
Agricultural	1,219	-0,029
	(1,917)*	(0,987)
GSCI	2,316	0,227
	(3,150)**	(1,098)

* significant at the 5% level
** significant at the 1% level

The only commodity futures class that did not perform substantially better during restrictive monetary policy periods was precious metals that in fact yielded negative higher returns during periods of expansive monetary policy although the mean return was negative also during expansive periods. The correlations reported in table 12 show that there are some changes in the relationships of the asset classes across monetary environments but the changes in correlations are not very substantial, especially for the most interesting asset classes, namely stocks, industrial metal futures and energy futures.

Table 13 reports the results of statistical tests that were performed to test for the significance of the return and risk differences reported in table 12. Standard t-tests were used to test the difference in mean monthly returns, and the results in table 13 indicate that the return differences for T-bills, industrial metal, energy and agricultural futures were statistically significant during different environments of monetary stringency. The standard deviations of returns were generally higher during restrictive periods of monetary policy for all asset classes except for agricultural futures, although the difference in standard deviations during different monetary policy periods was statistically significant indicated by an F-test only in the case of industrial metal futures. The observed risk differences, although not in all cases statistically significant, imply that restrictive monetary periods seem to coincide with periods of increased economic uncertainty.

Table 14 shows the optimal portfolio allocations for different asset classes in order to determine the role of different commodity futures classes in the optimal portfolio during periods of different monetary stringency during the study period. During restrictive monetary periods commodity futures play a prominent role in efficient portfolios representing more than 10% of the optimal portfolio in all cases and rising firmly as the portfolio risk is allowed to increase. Stocks represent only a small fraction of the optimal portfolio during restrictive monetary periods and the weight allocated to stocks becomes zero at 10% and higher yearly standard deviations. In contrast, Treasury bonds and T-bills are mixed with commodity futures in the efficient portfolios. Moreover, the commodity futures investments employed consist of industrial metals, energy, and livestock futures that increase their share of the optimal portfolio as the portfolio risk is increased during the restrictive monetary policy periods.

Table 14 also reports the portfolio returns when the weight of commodity futures is restricted to zero to enable a comparison of results. During restrictive monetary policy, the returns of the optimal portfolio including commodity futures would have rewarded the investors with substantially better returns than with a traditional investment mix ignoring commodity futures as an asset class. The return differential becomes larger as the portfolio risk increases being almost 10% on a yearly level at the 10% yearly portfolio standard deviation. This finding strongly supports the contention that some particular commodity futures classes should be included into the optimal portfolio during periods of restrictive monetary policy.

The results are as obvious during periods of expansive monetary policy. The optimal portfolio consists only of stock and T-bills, and the weight assigned to commodity futures is zero at all levels of risk. Clearly there is no difference in portfolio returns during expansive policy periods when the weight assigned to commodity futures is restricted to zero. The only striking result is that the weight assigned to Treasury bonds would have been zero during the period of study implying that an investor would have achieved no enhancement in the investment portfolio by giving an allocation to Treasury bonds.

It has become clear that monetary conditions can be used easily to improve the allocation given to different commodity futures classes in portfolios. The data dichotomised by monetary stringency showed that during expansive monetary periods commodity futures offer no benefit as a portfolio component. In great contrast, commodity futures largely dominate the optimal portfolio during restrictive monetary policy periods. Especially well-performing commodity futures classes have been industrial metals, energy and livestock. Figure 7 depicts graphically the message of this section by showing the improvement in the risk-return tradeoff when commodity futures are introduced to the investment mix. The attractiveness of utilizing commodity futures rises substantially as the portfolio risk level is allowed to increase.

The results in tables 12 and 13 are consistent with the findings that expected returns vary with changes in monetary policy. Moreover, the observed performance patterns are consistent with the existence of a systematic relationship between asset returns and monetary conditions as has been discussed in the sections on related research.[49] The existence of a systematic relationship is also supported by the relatively lengthy study period of 15 years. There are also seven discrete periods of monetary policy and the period includes times of differing economic conditions, which raises the confidence regarding the robustness of these results, even though the study period is not perfectly divided into an equal amount of expansive and restrictive monetary periods. Lastly, supporting the existence of a systematic relationship, the asset return patterns were found to be statistically significant in this study and also economically significant to an investor in monetary terms to an extent that makes them worth considering from a portfolio perspective.

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[49] The only inconsistency is the return patterns on bonds which did not behave as would have been expected if interpreting the regression results of for instance Jensen, et al. (1996) or Booth and Booth (1997).

TABLE 14

Optimal Portfolio Allocations across Monetary Environments

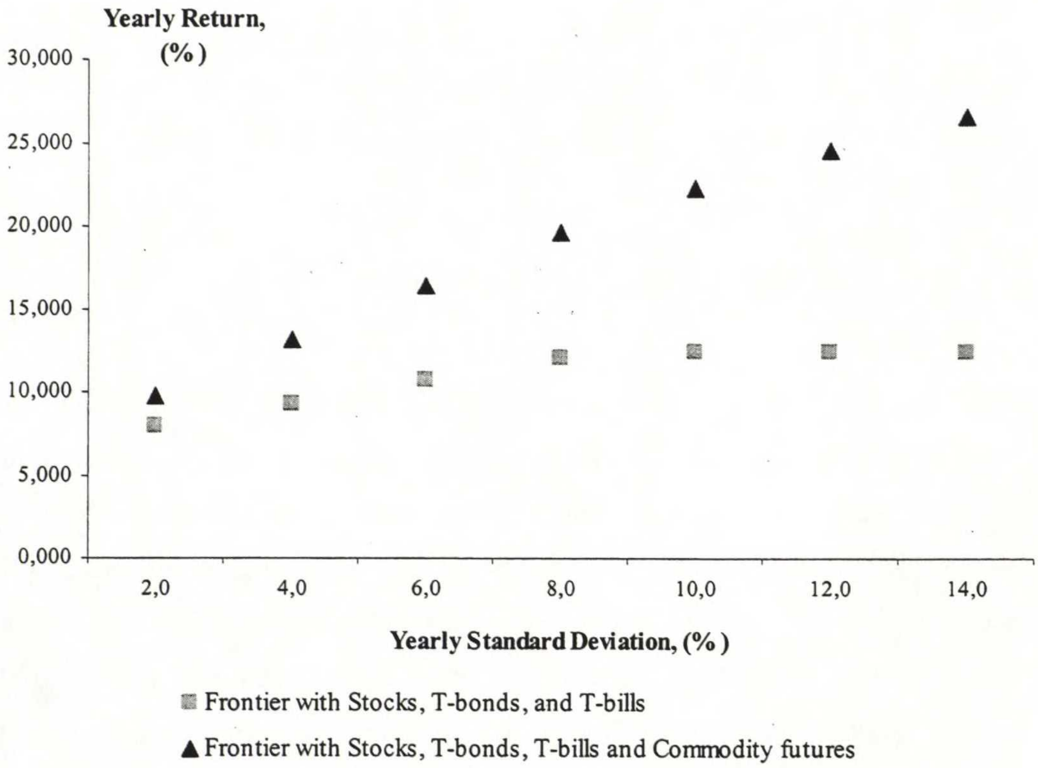
This table reports the optimal portfolio allocations for different asset classes during expansive and restrictive monetary periods yielded by Markowitz portfolio optimisation at a range of risk levels (defined by the standard deviation of the portfolio) during the period from February 1987 to 2002. Monetary policy is defined as expansive (restrictive) if the latest change in the Federal Reserve discount rate was a(n) decrease (increase) as defined by the directional rate-change dummy DIR. The months that included a change in the discount rate that had an opposite direction form the previous change were excluded from the analysis. Table 14 also reports the yearly return that each reported allocation would have yielded during the study period and an equivalent yearly return when the optimal portfolio would have been constructed only from stocks, bonds and T-bills (the weights assigned to each class are not reported).

Optimal Portfolio Allocation During Different Monetary Stringency Periods											
				Optimal Portfolio weights (%)							
Yearly Standard Deviation	Monetary Environment	Yearly Return for Portfolio without Commodity Futures (%)	Yearly Return for Portfolio with Commodity Futures (%)	Stocks	Treasury Bonds	T-bills	Precious Metals	Industrial Metals	Livestock	Energy	Agricultural
2,0	Expansive	6,084	6,084	13,190	0,000	86,810	0,000	0,000	0,000	0,000	0,000
	Restrictive	7,913	9,755	1,361	11,523	74,045	0,000	4,830	4,654	3,537	0,050
4,0	Expansive	7,465	7,465	27,314	0,000	72,686	0,000	0,000	0,000	0,000	0,000
	Restrictive	9,298	13,105	2,649	23,568	46,675	0,000	9,817	9,954	7,337	0,000
6,0	Expansive	8,838	8,838	41,349	0,000	58,651	0,000	0,000	0,000	0,000	0,000
	Restrictive	10,672	16,427	3,935	35,509	19,487	0,000	14,756	15,202	11,111	0,000
8,0	Expansive	10,208	10,208	55,361	0,000	44,639	0,000	0,000	0,000	0,000	0,000
	Restrictive	12,043	19,682	3,648	42,465	0,000	0,000	20,162	18,052	15,672	0,000
10,0	Expansive	11,577	11,577	69,364	0,000	30,636	0,000	0,000	0,000	0,000	0,000
	Restrictive	12,441	22,270	0,000	37,845	0,000	0,000	25,669	15,306	21,180	0,000
12,0	Expansive	12,946	12,946	83,363	0,000	16,637	0,000	0,000	0,000	0,000	0,000
	Restrictive	12,441	24,523	0,000	31,240	0,000	0,000	30,839	11,621	26,300	0,000
14,0	Expansive	14,315	14,315	97,359	0,000	2,641	0,000	0,000	0,000	0,000	0,000
	Restrictive	12,441	26,625	0,000	25,080	0,000	0,000	35,663	8,177	31,080	0,000

FIGURE 7

Efficient Frontiers during Periods of Restrictive Monetary Policy

This figure shows the improvement in the risk-return tradeoff associated with the introduction of commodity futures to the investment mix during periods of restrictive monetary policy indicated by the DIR variable. The frontiers were calculated by Markowitz portfolio optimization. The study period was between February 1987 to February 2002. The indexes used are described in section Description of Data. The weights assigned to each commodity futures class in the efficient portfolio are reported in table 14.



It is, however, important to be prudent and cautious when interpreting the results presented above. Although I have earlier provided evidence on the relationship between monetary conditions and returns in commodity futures and there are also previous findings suggesting that a systematic relationship exists, the findings of this section do not prove that this relationship truly exists or that it could be taken advantage of in the manner depicted here also in the future. The period of study is, however, relatively lengthy reducing the possibility of excessive influence of unusual observations, but the impact of randomness or pure luck is not, of course, eliminated. There always remains the possibility that the observed return patterns are purely coincidental.

Moreover, a question arises asking why there are specific futures classes that perform better than others. I believe that the relationship between for instance precious metals and monetary policy is less clearcut than is the case with for example energy. The reason for this is that there are no clearly huge producers in the precious metals markets and it seems to be more or less the central banks that are dumping for example gold to the market thus being a large long-hedger causing contango in the market. Factors of this sort make the precious metal markets behaviour different from that observed in the markets where there is a clear group of big producers. Last, the commodity futures markets that were influenced by economic variables the most appeared to be economically the most significant ones.

5.3 Analysis of the Robustness of The DIR Indicator

The interesting and appealing results of previous section motivate a further examination of the DIR variable to increase the confidence that it truly is an appropriate aggregate measure of monetary and economic conditions. The DIR indicator has been used in various studies in which it has been argued to be a good aggregate measure of monetary conditions [see e.g. Jensen et al. (1996), Booth and Booth (1997), and Durham (2000)]. Since commodities as such are often used as economic indicators[50], the robust differences in commodity futures returns when examined with the DIR variable can already be interpreted as an indication of the economic and monetary significance of the variable.

Table 15 summarizes the conditional mean values of the economic variables used in the study when the study period is dichotomised into expansive and restrictive periods as defined by the DIR variable. As can be seen, the means of all three monetary variables deviate significantly in different monetary environments, which I interpret as an indication that the DIR variable is a broad measure of monetary conditions. Similar inferences were made by Jensen et al. (1996) who used a similar method but different monetary variables in examining the DIR variable and its robustness as a broad measure of monetary stringency using data for the

[50] For example the Federal Reserve uses commodity price indexes as one of economic indicators to enable the formulation of a stabilizing monetary policy (Saxton, 2000).

TABLE 15
Tests for Differences in Means of Economic Variables in Different Monetary Environments

The differences in mean monthly values of economic variables[a] between periods of expansive and restrictive monetary policy were calculated as reported in this table. T-tests were used in testing whether the difference in mean values of economic variables deviates statistically significantly from zero and F-tests for the differences in standard deviations across economic variables during expansive and restrictive monetary policy periods. The study period was February 1987 to February 2002. The difference was calculated by subtracting the variable mean value for expansive periods from the equivalent mean value for the periods of restrictive monetary policy, where the monetary stringency was identified by the directional rate-change dummy DIR, implying that a month was expansive (restrictive) if the latest change in the Federal Reserve's discount rate was a(n) decrease (increase). Significance in test statistics is reported by the p-value associated with the particular test statistic.

Variable	Full Sample (n=180)	Expansive Periods (n=101)	Restrictive Periods (n=74)	P-value
Business conditions proxy:				
D/P	2,466	2,245	2,770	0,000
TERM	1,635	2,017	1,125	0,000
DEFAULT	1,844	1,846	1,836	0,444
Monetary policy indicator:				
FFRATE	5,683	4,735	6,942	0,000
FFPREM	0,299	0,220	0,400	0,000
FFSPR	1,339	1,798	0,730	0,000

[a]See the section Description of the Data or tables 6 and 7 for the definitions of the variables

period from 1954 through 1992. Once more, DIR seems to also differentiate the monetary conditions with this somewhat different subset of monetary indicators.

The results for the business condition proxies are somewhat less robust. First, the term spread is statistically significantly higher during expansive monetary periods much like the federal funds spread. This may further indicate that the Term variable bears a monetary component to it, which has also been suggested in previous research. On the other hand, the Default variable does not really behave significantly differently during the two different periods of monetary stringency, whereas the D/P variable has very significantly different means but not to the direction that might be first predicted.[51] As a conclusion, it seems that the business condition variables' behaviour does not seem to be altered to a very large extent with changes in the DIR variable.

[51] D/P has a lower mean during expansive periods, which are normally characterized as favorable for stock expected returns. On the other hand, a low dividend yield would predict lower stock returns. However, as the relationship is not a very facile one, the dividend yield should not probably even be considered as a true predictor of the real economy and should perhaps be omitted from the robustness analysis of the DIR indicator.

In conclusion, the short analysis of this section raises our confidence that the DIR variable truly acted as an indicator and reflected monetary stringency and contemporary monetary conditions during the period of study. This will further imply that the relationship between monetary policy and futures returns seems to be of more systematic type and apparently not a pure coincidence.

5.4 Discussion of the Results

The main information given by the analysis of the previous sections was the finding of predictability in energy and industrial metal markets captured by variables that have been previously shown to possess forecast power across stock and bond markets. The results of the primary research question can be summarised by stating that

- many economic variables that have been shown to forecast expected returns on stock and bond markets capture variation in expected returns on energy, industrial metal, and the GSCI futures markets (although at times relatively weak, still statistically significant; see tables 6-8)
- the variables that forecast returns move in dissimilar cycles across asset classes suggesting revision of portfolio allocations depending on the state of the economy (see table 9).

This means that the null hypothesis on both hypothesis 1 and 2 could be rejected for energy, industrial metal, and the GSCI futures.[52] For precious metal, agricultural, and livestock futures the null hypotheses were accepted.

The empirical part in section 5.2.1. examined the attractiveness of commodity futures in portfolios, and the results to the secondary research question suggest that

- the addition of commodity futures to the investors investment mix enhances the portfolio risk-return tradeoff at a range of risk levels. All commodity futures classes are, however, relatively poor as stand-alone investments.

This implies that the null hypothesis of no enhancement in the risk-return tradeoff by the incorporation of commodity futures can be rejected.

[52] This of course depends on the chosen significance level, but the cumulative evidence from all sets of regressions supports the decision to reject the null hypothesis.

The attractiveness of commodity futures was greatly enhanced when monetary policy guided the allocation process and I illustrated how predictable variation can be taken advantage of by showing that

- a trading strategy that changes allocations between traditional assets and commodity futures depending on monetary policy would have capitalized on predictable variation of different assets during the past 15 years.

The empirical part of the study proceeded as depicted in figure 1. We first found an answer to the primary research question by examining the hypotheses 1 and 2, and then provided the secondary research question with a solution by examining hypothesis 3. These findings then led to the derived research question that gave further insight to the underlying research questions as depicted in figure 1.

A theoretical motivation and discussion of the results still remains. In his article Efficient Capital Markets II, Fama (1991) suggests that the return predictability reflects either variation across time in equilibrium expected returns or deviations of price from value that is irrational, or some combination of the two. If the predictability is rationally driven by shocks to taste and technology, Professor Fama argues, it should be common across markets and be related to changes in consumption, investments, and savings. One puzzle that the results of this study present is the finding of predictability of returns in two commodity futures markets that was opposite in sign to the predictability in stocks and bonds. This could be theoretically interpreted with a link to the market segmentation theories[53] by arguing that the commodity futures markets have different preferences in terms of consumption, investments, and savings.[54]

Although interpretations of these results could be disparate[55], I think that the theories of commodity market imperfections[56] suggesting that the marginal investor differs across

[53] For instance Hirsleifer (1988) presents an equilibrium model that incorporates some market imperfections resulting to segmentation of commodity futures from asset markets.

[54] Alternative argument would be that futures market equilibrium price bias is a function of hedging pressure that acts differently in economic states or that the monetary forecast variables happened to capture unexpected inflation which caused the observed return patterns on commodity futures holdings.

[55] Interpretations could start from criticism concerning the length of the study (15 years) suggesting a possible statistical coincidence.

equities/bonds and futures may be most appropriate in putting the findings into the right light. I believe, however, that the most important suggestion made by the results is the support to incorporating commodity futures into an investment portfolio, and furthermore, using monetary policy or monetary stringency as a guide to help allocating capital to commodity futures taking advantage of lower (higher) ex ante returns on traditional assets at times of more (less) stringent monetary policy.

Last, a critical question for the interpretation of the results is why only industrial metal and energy futures returns could be predicted by economic variables. A specific answer to this question would be needed to truly validate the results and prove that the relation between returns and economic variables is systematic. The answer could possibly be found from the differences between the features of different futures markets.[57] An exact answer will, however, require a deeper understanding of the economic importance of the different commodities and the reasons for the predictability and rational variation in expected returns in all different markets.

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[56] If the reader is reluctant to believe that market imperfections are a real phenomenon, it must be noted that very influential academics have tackled these issues. The presidential address to the American Finance Association by Robert Merton (1987) models security pricing when investors only hold the securities they know enough about. Furthermore, he discusses the pervasiveness of informational barriers to investing in an otherwise attractive security and how the informational barriers may be of long duration. Articles like that of Mr. Merton support the idea that there must be areas of financial markets that must enable the standard investor to achieve better asset allocations which are bound to be surrounded by informational, institutional, or regulatory barriers, all of which are to an extent part of commodity futures markets.

[57] For instance, hedging pressure would certainly differentiate between energy products in which hedging pressure would be likely to be significant and precious metal markets in which for example the gold markets have had a subdued performance largely because of a general trend among central banks to reduce the allocation to gold in their asset portfolios.

6 CONCLUSIONS

This study relates closely to research that has examined the relationship between risk premiums of securities and changes in business conditions or monetary policy. Earlier evidence by various researchers has shown how expected returns on different assets change and can be predicted depending on contemporary monetary policy or business conditions. Furthermore, the variation in expected returns conditional on changes in the underlying economy has also been argued to be rational by many of the findings. The examination of predictability in commodity futures in this study showed that monetary and financial variables produce a mix of variation in expected returns on energy and industrial metal futures markets.

The still largely unanswered questions of this study are why the forecast power was not significant on the three other futures markets, and how come the predictable variation in futures markets moved in somewhat dissimilar cycles compared to stocks and bonds identified in earlier studies. These issues were discussed in the light of theoretical models and empirical findings that report the futures price bias to be different from that predicted by the perfect-markets models due to market imperfections that effectively make commodity futures markets segmented from traditional asset markets. This is just one possible explanation of many and it remains for future research to re-examine the results and find a valid theory for the phenomenon.

An important and useful result, however, is the suggestion of this study that commodity futures should be incorporated into investment portfolios. Furthermore, the results suggest that investors should use monetary policy or monetary stringency indicators as guides to help in allocating capital to commodity futures taking advantage of inflationary environments, higher ex ante returns on commodity futures, and lower ex ante returns on traditional assets at times of more stringent monetary policy. This finding is supported by early findings that date back to the 1960's and 1970's when investors first acknowledged the good performance of commodity futures in certain (inflationary) economic environments.

Many questions remain open after this study. Fama (1991) argues that rational variation is caused by shocks to tastes for current versus future consumption or by technology shocks. To develop the issues examined in this study further, we can hope to establish more facts about the links between macroeconomic variables and expected returns in general and connect these findings also to commodity futures markets. After all, the variation in expected returns should be common across markets, if rational (Fama, 1991). In my view, the questions we would want to be answered in a rather detailed way are

1. If predictable variation is rational, why can we observe it in just two of the five commodity futures markets examined? Furthermore, should there even be predictable variation in commodity futures markets? We can either hope to create a more coherent story that supports the finding of predictable variation in commodity futures and the traditional asset markets, or reassure ourselves that no such story exists. The answer to these question will no doubt come only after the finance community has come to a consensus concerning the whole underlying story of predictable variation and has come to understand the peculiarities of different commodity futures markets more precisely.
2. Why do the economic variables capture expected returns that move in dissimilar cycles in energy and industrial metal futures markets compared to stocks and bonds? If the variation traces back to shocks to tastes for current versus future consumption or shocks to technology, should it not be common across markets if markets are integrated and investors rational?
3. What is the role of monetary policy to return predictability in all markets [Returns are predictable according to earlier research, but why? It all boils down to the question of the relation between monetary policy and the real economy, in the opinion of many researchers. See e.g. Patelis (1997) or Fama (1991)] and returns in commodity futures? I think the latter part of the question must address the relation between monetary policy and inflation and the predictive power of monetary variables on expected and unexpected inflation. The former part of the question still relates to the link between monetary policy and real economy, and real economy and asset return predictability.

The study of commodity futures, predictable variation in returns, and the role of monetary policy in determining the two creates a formidable research agenda. The economic importance of commodities makes understanding them important and the institutional features of commodity markets starting from the big role played by the producers makes understanding commodity related products, for example futures, sometimes harder. Furthermore, commodity futures are still waiting to become truly accepted as a legitimate asset class by the standard investor. The results of this study and those of some influential predecessors, however, imply that commodity futures may prove to be a valuable addition to the standard portfolio.

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APPENDIX 1: The Goldman Sachs Commodity Index

The source for the following information is the Goldman Sachs web-page www.gs.com.

The Goldman Sachs Commodity Index (GSCI) is a composite index of commodity sector returns, representing an unleveraged, long-only investment in commodity futures that is broadly diversified across the spectrum of commodities. It is designed to provide investors with a publicly available benchmark for investment performance in the commodity markets comparable to for example S&P 500 or DAX equity indexes.

The GSCI is a world-production weighted index, the analogue of market capitalization weighting for equities, and the quantity of each commodity in the index is determined by the average quantity of production in the last five years of available data. The GSCI contains as many commodities as possible, with the rules excluding commodities only to retain liquidity and investability in the underlying futures markets. Currently, the GSCI contains 26 commodities from all commodity sectors, namely, six energy products, nine metals, and eleven agricultural products. The broad range of constituent commodities provides the GSCI with a high level of diversification both across subsectors and within each subsector. The diversification of the index and subindexes minimizes the effects of highly idiosyncratic events, which would have large implications for the individual futures contracts, but are muted when aggregated to the level of the subindex or the aggregate GSCI.

The GSCI returns are calculated based on the arithmetic average of the returns of long positions in front-month futures contracts. The expiring contracts are rolled forward into the next nearby futures contracts over a five-day roll period on the fifth to ninth business day of each month. The rolls occur at a rate of 20% per day and the rolling is done using the official closing futures prices. The final GSCI total return is calculated by adding the T-bill return to the return obtained from the long position in the futures contract. This return is a fully collateralized return and is therefore comparable to the returns earned from long-investments in stocks and bonds.